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A COMPUTER BASED STORAGE AND RETRIEVAL SYSTEM FOR ATHLETIC INJURY DATA:
ANALYSIS OF COLLEGIATE SOCCER INJURIES

David Saul Weiss

1981

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A COMPUTER BASED STORAGE AND RETRIEVAL SYSTEM FOR ATHLETIC INJURY DATA:

ANALYSIS OF COLLEGIATE SOCCER INJURIES

David Saul Weiss

A Thesis Submitted to
The Yale Unversity School of Medicine
In Partial Fulfillment of
The Requirement for the Degree of
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ABSTRACT

Using the present resources and organization of the Department of Athletic Medicine at Yale University, we have designed and introduced a computer based storage and retrieval system for athletic injury data, applying a case record approach. Designed to provide a comprehensive data base for future studies, the system allows the selective retrieval of data fulfilling criteria in any one or all of sixteen categories describing the circumstances surrounding the injury and the type of injury. A multiaxial description of the injury is recorded using a modified subset of the Systematized Nomenclature of Medicine. We describe here the methods and computer programs (software) developed specifically for this purpose and give examples of the system's capabilities. As an in depth example of the application of this system, a study of injuries during one season of collegiate soccer is presented. No significant differences between the rates of injury for the three groups varsity and junior varsity men, varsity women, and intramural athletes is found. Significantly more injuries are found to occur during competition versus practice and on artificial turf versus grass.

To

Barbara Seibert

"Ballet is one place where art flourishes because of a woman: woman is the goddess, the poetess, the muse."

George Balanchine

ACKNOWLEDGEMENT

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PART I

A COMPUTER BASED STORAGE AND RETRIEVAL SYSTEM FOR ATHLETIC INJURY DATA

INTRODUCTION

Historical

Organized athletics has been an important part of the educational process since early in recorded history. A recent study[1] under the auspices of the Department of Health, Education, and Welfare estimates that athletic activities result in approximately 200,000 injuries at the college level each year. However, few colleges have any way to assess the effect of athletics on the health and well-being of their students. The medical literature contains no recent comprehensive studies on the occurrence of collegiate athletic soccer injuries or any descriptions of systems capable of collecting such data. Early studies which relied on manual tabulations as well as recent studies utilizing computers have been limited to recording at most one or two parameters of injuries for all sports or several parameters of a single sport.

In the classic study by Thorndike[2-4], a total of 8293 injuries amongst all athletes at Harvard University were tabulated from 1932 through 1959. The only parameters recorded were the type of injury, sport, and the part of the body injured. MacIntosh _et al._[5] reported on injuries in all sports at the University of Toronto between 1951 and 1968. In addition to the parameters collected by Thorndike, the following were recorded: date of injury, level of competition (intercollegiate or intramural), and whether or not the injury was recurrent.

Among the studies of a single sport, many were limited to a single season or year. Hibbert[6] analyzed the injuries to high school football players during one season with reference to age and personal experience.

Johnson and Ritter[7] studied the incidence of injuries to Indiana University football players with respect to player position. Very few studies have been able to accomplish physician recording or review of injuries. Allen[8], himself a physician, did attend all practice sessions and games in his study on the Air Force football team over one and a half seasons.

Studies using computers for collection and storage of injury data have also been reported. Farmer[9] described a simple system developed at the California State University based on the library program SPSS (Statistical Package for the Social Sciences). Although apparently ongoing, neither a description of data being collected nor any data analysis have been reported. Kranz _et al_.[10] reported on a similar system with SPSS and described a sophisticated data collection form that is processed by an optical reader. Again, no data analyses have appeared in the literature. Kraus and Burg[11] presented a comprehensive coding form for the National Tackle Football Injury surveillance program and discussed the problems associated with data collection and injury classification. Here again, there is no data presented and there have been no subsequent reports in the literature.

Clarke[12-15] apparently has designed an ambitious computerized program known as the National Athletic Injury/Illness Reporting System (NAIRS). It appears to have been developed with an eye towards the then newly formed U. S. Consumer Product Safety Commission and the federal legislation mandating a national study of injuries in scholastic athletic programs.[16] This study eventually was performed separately by the National Center for Education Statistics[1] for the Department of Health, Education, and Welfare but with the assistance of Dr. Clarke. No reports of NAIRS methods have appeared in the literature. From

documents obtained,[13,14] it seems that NAIRS is a comprehensive data collection system based on extensive somputer software (programs). Injuries are recorded by athletic trainer at high school and colleges across the country and forwarded to NAIRS weekly. Also sent are lists of the numbers of athletes, practices, and games. This enables the easy generation of statistics (such as injuries per 100 athletes or per 1000 athlete exposures) where the injuries themselves have never been reviewed by a physician or in any way verified. Retrieval of subsets of data, for example, all injuries of a specific type, appears to be difficult and has discouraged some schools from continuing their participation. Recently, the first analysis of data collected by NAIRS was published[16], a study of women's injuries in college sports from 1975 through 1978.

Data Collection and Management

The absence of any comprehensive, accurate system for analyzing athletic injuries can be ascribed to the tremendous complexity of developing a system applicable to all sports that collects, stores, and allows the selective retrieval of injury data. The information necessary to build a universal data base is quite extensive. One would need to collect demographic data on each athlete: name, age, class year, sex, height, and weight. Information about the occurrence of the injury would include date, time, place, sport (and event for sports like gymnastics and track), level of competition (e.g. varsity, intramural, club), sex of team, position played, equipment (type and age), occasion (e.g. practice, competition, first quarter, late in match), activity (e.g. running, jumping, sliding), situation (e.g. kick-off, penalty kick, squeeze bunt), field

surface type, field condition, and weather (temperature, humidity, precipitation). A description of the injury itself would also be obtained: nature (e.g. new, recurrence), diagnosis (classification of injury), part of body affected, cause (e.g. equipment, opponent, teammate), severity, time lost, and management.

Other parameters to be considered are dependent on the methods of data collection. If the information is to be coded at different locations (e.g. field, field house, student health center) it may be desirable to note this. Differences in coding by various personnel (e.g. coach, trainer, physician) should suggest recording the identity of the responsible person in each case. If injuries are coded at different time intervals following the event, this should be noted so that early estimates of severity and time lost will not be mininterpreted.

A set of standard choices must be provided for each parameter; these must be applicable to all sports. In most instances this is easily accomplished, but for some parameters (such as activity, surface type and condition) this may be more difficult, and in some cases (such as position played, equipment, and situation) this may be all but impossible. For these last mentioned categories it must be decided whether to have alternate choices (and therefore alternate code sheets or books) for each sport or whether to eliminate these parameters.

Problems are invariably encountered in the classification of the injury. Studies will be most flexible if a large amount of data about each injury diagnosis is recorded and easily retrievable. In this way data analysis at a subsequent date can be undertaken to review and correctly classify the injuries, eliminating recorder bias. Some studies have relied on the review of medical records to collect injury

data. This will be accurate only if all injuries have been recorded and, more importantly, can be found. Unfortunately, the shear manual task of screening records will obviously place limits on the extent of such a study.

Most studies have employed a standard set of injury classifications. The Standard Nomenclature of Athletic Injuries,[17] containing approximately 575 terms, and the International Classification of Diseases[18] are the usual sources for the derivation of a subset of categories. Injuries are classified upon presentation or shortly thereafter. This simplifies storage in that only one descriptive term or code need be recorded, but may result in errors due to inaccurate diagnosis and failure to recognize recurrences. Retrieval of specific data for separate analyses is hindered in such a system by the use of broad statistical categories which provide little descriptive information about the injury.

One solution to these difficulties may be the use of a nomenclature that employs several descriptive terms in separate areas to synthesize a conception of the injury. Such a system, termed multiaxial, has the advantage of providing maximal detail including complex relationships (because of the almost infinite number of combinations) as well as the ability to be simplified to suit a particular application. In use, one must be aware of the need to store more digits of code and to consult several lists of terms to express one concept.

The Systematized Nomenclature of Medicine (SNOMED) is an elaborate multiaxial system composed of seven axes (four basic axes plus three accessary ones) as well as qualifying and linkage terms.[19-21] Axis 1 is an anatomic nomenclature known as Topography which contains almost ten thousand terms and provides extremely detailed descriptions of parts

Table 1

Partial Topographic Nomenclature of Bones of the Lower Extremity

117-119 Bones of Lower Extremity

T-11700	Bone of lower extremity, NOS
T-11701	Bone of ankle, NOS Ankle bone, NOS
T-11710	Femur, NOS
T-11711	Head of femur
T-11712	Neck of femur
T-11713	Greater trochanter of femur
T-11714	Lesser trochanter of femur
T-11715	Intertrochanteric line of femur
T-11716	Intertrochanteric crest of femur
T-11717	Shaft of femur
T-11718	Medial epicondyle of femur
T-11719	Lateral epicondyle of femur
T-11720	Patella, NOS Knee bone, NOS
T-11721	Apex of patella
T-11722	Medial articular facet of patella
T-11723	Lateral articular facet of patella
T-11724	Base of patella
T-11730	Tibia, NOS
T-11731	Medial condyle (plateau) of tibia
T-11732	Lateral condyle (plateau) of tibia
T-11733	Intercondylar spine of tibia
T-11734	Medial malleolus
T-11735	Tibial tuberosity
T-11736	Shaft of tibia
T-11737	Superior articular facet of tibia with fibula
T-11738	Inferior articular facet of tibia with fibula
T-11739	Malleolar articular surface of tibia
T-11740	Fibula, NOS
T-11741	Head of fibula
T-11742	Articular facet of head of fibula
T-11743	Apex of head of fibula
T-11744	Shaft of fibula
T-11745	Lateral malleolus
T-11746	Malleolar articular facet of fibula
T-11747	Posterior malleolus of fibula
T-11750	Tarsal bone, NOS
T-11755	Bone of foot, NOS Foot bone, NOS
T-11760	Calcaneus, NOS Os calcis
T-11761	Calcaneal tubercle
T-11762	Medial process of calcaneal tubercle
T-11763	Lateral process of calcaneal tubercle
T-11764	Sustentaculum tali
T-11765	Anterior articular surface for talus
T-11766	Middle articular surface for talus
T-11767	Posterior articular surface for talus
T-11768	Groove for flexor hallucis
T-11769	Cuboidal articular surface of calcaneus
T-11770	Talus, NOS
T-11771	Head of talus
T-11772	Neck of talus
T-11773	Body of talus
T-11774	Os trigonum
T-11775	Posterior calcaneal articular surface of talus
T-11776	Middle calcaneal articular surface of talus
T-11777	Anterior calcaneal articular surface of talus
T-11778	Navicular calcaneal articular surface of talus
T-11779	Posterior tubercle of talus
T-11780	Cuboid, NOS
T-11781	Tuberosity of cuboid bone
T-11782	Calcaneal facet of cuboid bone
T-11783	Fourth metatarsal facet of cuboid bone
T-11784	Fifth metatarsal facet of cuboid bone
T-11785	Third cuneiform facet of cuboid bone
T-11786	Navicular facet of cuboid bone
T-11787	Accessory cuboid bone
T-11790	Navicular bone of foot, NOS
T-11791	Tuberosity of navicular bone of foot
T-11792	Talar facet of navicular bone of foot
T-11793	First cuneiform facet of navicular bone of foot
T-11794	Second cuneiform facet of bone of foot
T-11795	Third cuneiform facet of navicular bone of foot
T-11796	Cuboid facet of navicular bone of foot
T-11797	Accessory navicular bone of foot
T-11810	Lateral cuneiform bone, NOS Third cuneiform bone, NOS
T-11811	Second metatarsal facet of lateral cuneiform bone
T-11812	Third metatarsal facet of lateral cuneiform bone
T-11813	Fourth metatarsal facet of lateral cuneiform bone
T-11814	Cuboidal facet of lateral cuneiform bone
T-11815	Navicular facet of lateral cuneiform bone
T-11816	Cuneiform facet of lateral cuneiform bone
T-11820	Medial cuneiform bone, NOS First cuneiform bone, NOS
T-11821	First metatarsal facet of medial cuneiform bone
T-11822	Second metatarsal facet of medial cuneiform bone
T-11823	Second cuneiform facet of medial cuneiform bone
T-11824	Navicular facet of medial cuneiform bone
T-11830	Intermediate cuneiform bone, NOS Second cuneiform bone, NOS
T-11831	Second metatarsal facet of intermediate cuneiform bone
T-11832	First cuneiform facet of intermediate cuneiform bone
T-11833	Third cuneiform facet of intermediate cuneiform bone
T-11834	Navicular facet of intermediate cuneiform bone
T-11840	Metatarsal, NOS
T-11850	First metatarsal bone, NOS
T-11851	Tuberosity of first metatarsal bone
T-11852	Base of first metatarsal bone
T-11853	Shaft of first metatarsal bone
T-11854	Head of first metatarsal bone

Table 2

Partial Morphologic Nomenclature of Fractures

12 FRACTURE
120 Fractures

5th digit (1200-1289)
0 NOS
1 congenital
2 with displacement
3 with dislocation
4 pathologic
5 stress
6 healing

M-12000	Fracture, NOS
M-12010	Fracture, transverse
M-12020	Fracture, oblique
M-12030	Fracture, spiral
M-12040	Fracture, longitudinal Fracture, linear
M-12050	Fracture, impacted Fracture, compressed
M-12060	Fracture, intra-articular Fracture, articular
M-12070	Fracture, incomplete Fracture, greenstick
M-12080	Fracture, segmental
M-12090	Fracture, comminuted

121 Closed Fractures

M-12100	Fracture, closed, NOS
M-12110	Fracture, closed, transverse
M-12120	Fracture, closed, oblique
M-12130	Fracture, closed, spiral
M-12140	Fracture, closed, longitudinal Fracture, closed, linear
M-12150	Fracture, closed, impacted Fracture, closed, compressed
M-12160	Fracture, closed, intra-articular Fracture, closed, articular
M-12170	Fracture, closed, incomplete Fracture, closed, greenstick
M-12180	Fracture, closed, segmental
M-12190	Fracture, closed, comminuted

122 Open Fractures

M-12200	Fracture, open, NOS
M-12210	Fracture, open, transverse
M-12220	Fracture, open, oblique
M-12230	Fracture, open, spiral
M-12240	Fracture, open, longitudinal Fracture, open, linear
M-12250	Fracture, open, impacted Fracture, open, compressed
M-12260	Fracture, open, intra-articular Fracture, open, articular
M-12270	Fracture, open, incomplete Fracture, open, greenstick
M-12280	Fracture, open, segmental
M-12290	Fracture, open, comminuted

123 Ununited Fractures

M-12300	Fracture, ununited, NOS
M-12360	Fracture, ununited, intra-articular Fracture, ununited, articular
M-12380	Fracture, ununited, segmental
M-12390	Fracture, ununited, comminuted

124 Delayed Union Fractures

M-12400	Fracture, delayed union, NOS
M-12410	Fracture, delayed union, transverse
M-12420	Fracture, delayed union, oblique
M-12430	Fracture, delayed union, spiral
M-12440	Fracture, delayed union, longitudinal Fracture, delayed union, linear
M-12450	Fracture, delayed union, impacted Fracture, delayed union, compressed
M-12460	Fracture, delayed union, intra-articular Fracture, delayed union, articular
M-12470	Fracture, delayed union, incomplete Fracture, delayed union, greenstick
M-12480	Fracture, delayed union, segmental
M-12490	Fracture, delayed union, comminuted

125 Healed Fractures

M-12500	Fracture, healed, NOS
M-12520	Fracture, healed, fibrous union Fibrous union
M-12560	Fracture, healed, intra-articular Fracture, healed, articular
M-12590	Pseudoarthrosis

126 Miscellaneous Fractures

M-12610	Chip fracture
M-12620	Avulsion fracture

128 Multiple Fractures

M-12800	Fracture, multiple, NOS Fracture, multiple, bone Fracture, multiple bone sites Fracture, multiple, right arm (T-Y8010)
M-12810	Fracture, multiple, closed
M-12820	Fracture, multiple, compound
M-12830	Fracture, multiple, closed & compound

137-139 Eponymic Fractures and Dislocations

M-13700	Barton's fracture
M-13710	Bennett's fracture
M-13720	Colles' fracture
M-13730	Colles' fracture, reversed Smith's fracture
M-13740	Dupuytren's fracture, NOS Pott's fracture
M-13750	Dupuytren's fracture of forearm Galeazzi's fracture

of the body; Table 1 provides some examples of these terms. Axis 2 describes abnormalities in the form or structure of the body (such as traumatic, developmental, mechanical, and other defects) and is called Morphology (Table 2). Axis 3 provides a list of causes and agents responsible for injury and disease and is known as Etiology. Axis 4, Function, contains descriptions of all normal and abnormal functions of the body. These four axes form the core of the nomenclature and can be used in combination to describe almost all lesions. In addition they provide superb retrieval capability based on any individual axis. For example, one could search for all injuries with Topography coded as "knee," or as "ligament," or Morphology coded as "closed fracture," or as "contusion."

Axis 5, Disease, provides a list of diseases, disease complexes, and syndromes. The terms it contains are not necessary to describe most athletic injuries. Axis 6, Procedure, is an exhaustive list of diagnostic and therapeutic measures and is ideal when used to describe injury management. Axis 7, recently added to SNOMED and called Occupation, lists various job and employment categories and is not particularly applicable to athletic problems. Finally, information qualifiers (e.g. "history of...," "no evidence of...," "x-ray diagnosis," "final diagnosis") and syntactic linkage terms (e.g. "due to," "associated with," "consistent with," "complicated by") may be used to modify any terms.

SNOMED's four core axes plus Procedure will provide an excellent method to store injury diagnosis and management. Demographic data (such as sport, occasion, activity) can each be thought of as an additional, separate axis whose terms would be selected to completely describe the sample population. Analogous to Occupation, these axes would not describe

the injury itself, but rather delineate the circumstances surrounding the injury.

Significant problems often arise in the actual collection of the data. A system must be devised so that all or virtually all injuries are recorded. This will depend on the personnel available. Coaches have the most access to the athletes, but usually are not highly enough trained to make an accurate diagnosis and estimate of severity. Nurses, trainers, and physicians are the appropriate persons to supply data on diagnosis, severity and management, but are a scarcer commodity. Most ofter the best description of the circumstances surrounding the injury comes from the athlete him or herself; this is a resource that should not be overlooked.

Injuries may be recorded on the field, in the training room or field house, or at a student health center. Immediate recording may insure few "lost cases" but does not allow an accurate determination of many parameters. Collection of data in a training room or field house allows evaluation by a nurse or trainer, ofter supervised by a physician, but important diagnostic methods are usually still not available. Recording injuries at a student health service allows full access to diagnostic facilities and excellent extended follow-up of serious injuries. This method will often result in a significant case loss of minor injuries such as abrasions, lacerations, and stiff muscles. However, these do not result in any lost practice or competition time and are usually excluded from studies.

Injury data, once collected, must be stored so as to be readily available for retrieval and analysis. In the past it was common for injuries to be written and cross referenced on cards, but this obviously

placed extreme limitations on selective retrieval of data. Recently, studies have utilized digital computers whose high speed make vast data searches theoretically possible. Unfortunately, most have used computers only for blind statistical calculations, ignoring the large storage capacity of these machines. The computer can be programmed ("software") to store injury data and retrieve specific information as requested.

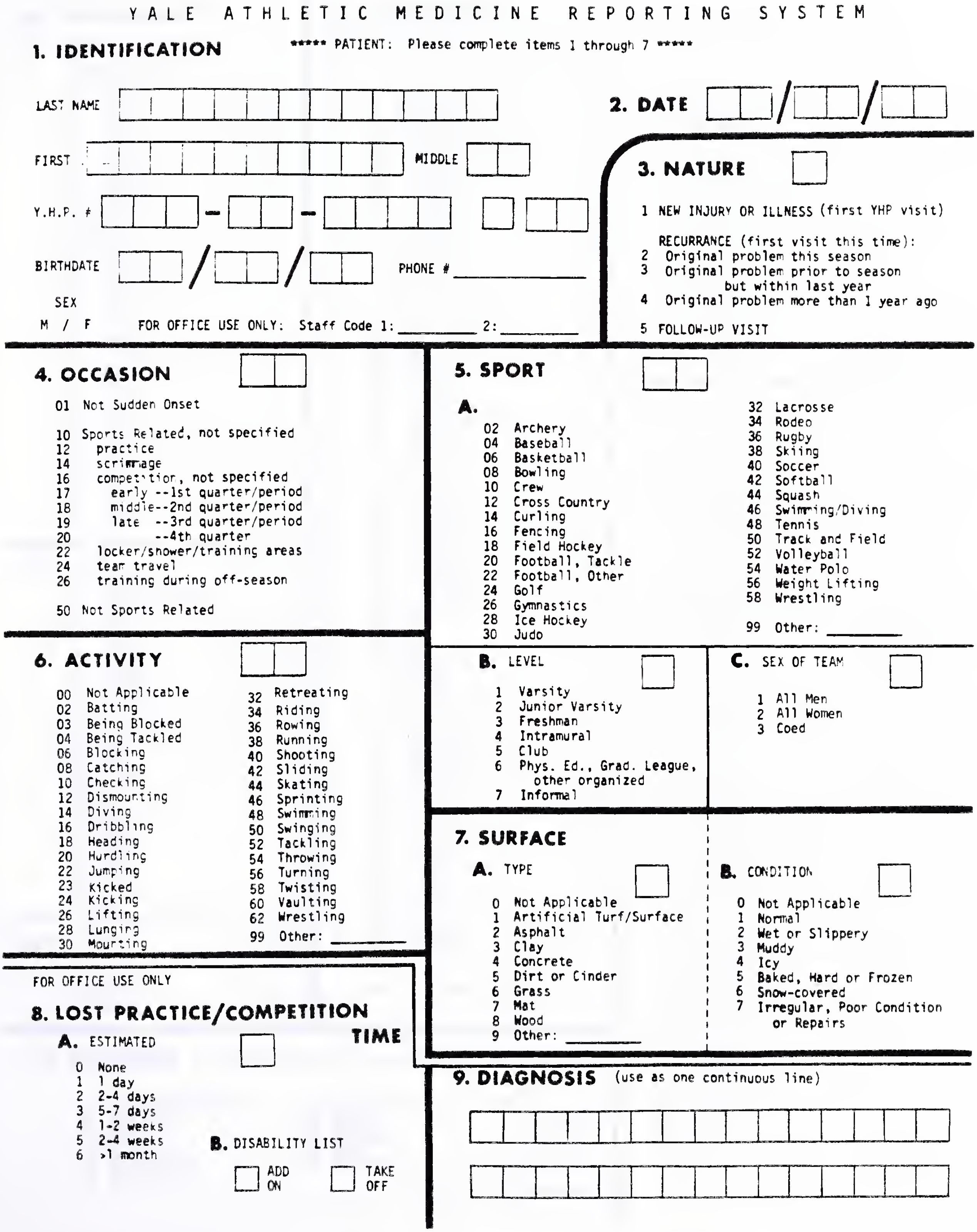
Most studies have published tabulations of injuries in one or more sports. With a properly designed computer system interesting correlations might be obtained if one could search, for instance, for all injuries occurring on a specific field type or surface condition, while the athlete was performing a certain activity, or during a specific phase of practice or competition. Similarly, storing a multiaxial description of injury diagnosis should allow the retrieval of all injuries to a specific body region or tissue, resulting in a certain morphologic or functional abnormality, caused by a single etiologic factor, or requiring a specific diagnostic or therapeutic procedure.

METHODS

Design

The Department of Athletic Medicine, comprised of physicians, athletic trainers, and nurse practitioners, is responsible for the health of all student athletes at Yale University. A clinic is staffed six days per week at the University Health Service for the exclusive use of intercollegiate, intramural, and informal athletes. Trainers, under the supervision of a physician, oversee all activities on the field and staff the training room. Physicians cover all home games and selected practices and also review all cases seen in the clinic. Any injury resulting in one or more days of lost time is referred to the athletic medicine clinic. For this reason, it is most practical to develop an injury reporting system based on individual visits to this clinic. It was decided in order to simplify reporting that one form and one set of codes would be used for all athletes in all sports. Thus certain data applicable to a universal data base, such as position played, event, equipment, and game situation, could not be collected. Similarly, some categories, such as activity, surface type, and surface condition, had to include terms applicable to all sports.

The coding form is shown in Figure 1 and 2; a summary of the data collected is listed in Table 3. Identifying information for each athlete included full name, social security number (for internal use only), birthdate, and sex. A description of the circumstances surrounding the injury is also collected, as this data is very rarely available in the medical record. Since the athlete is usually the best source of this information, he or she is asked to select the codes in these categories. The physician



YALE ATHLETIC MEDICINE REPORTING SYSTEM

1. IDENTIFICATION ***** PATIENT: Please complete items 1 through 7 *****

LAST NAME ☐☐☐☐☐☐☐☐☐☐☐☐

FIRST ☐☐☐☐☐☐☐☐☐☐ MIDDLE ☐☐

Y.H.P. # ☐☐☐ – ☐☐ – ☐☐☐☐ ☐ ☐☐

BIRTHDATE ☐☐/☐☐/☐☐ PHONE # ________

SEX

M / F FOR OFFICE USE ONLY: Staff Code 1: ________ 2: ________

2. DATE ☐☐/☐☐/☐☐

3. NATURE ☐

1 NEW INJURY OR ILLNESS (first YHP visit)

RECURRANCE (first visit this time):
2 Original problem this season
3 Original problem prior to season but within last year
4 Original problem more than 1 year ago

5 FOLLOW-UP VISIT

4. OCCASION ☐☐

01 Not Sudden Onset

10 Sports Related, not specified
12 practice
14 scrimmage
16 competition, not specified
17 early --1st quarter/period
18 middle--2nd quarter/period
19 late --3rd quarter/period
20 --4th quarter
22 locker/shower/training areas
24 team travel
26 training during off-season

50 Not Sports Related

5. SPORT ☐☐

A.

02 Archery
04 Baseball
06 Basketball
08 Bowling
10 Crew
12 Cross Country
14 Curling
16 Fencing
18 Field Hockey
20 Football, Tackle
22 Football, Other
24 Golf
26 Gymnastics
28 Ice Hockey
30 Judo
32 Lacrosse
34 Rodeo
36 Rugby
38 Skiing
40 Soccer
42 Softball
44 Squash
46 Swimming/Diving
48 Tennis
50 Track and Field
52 Volleyball
54 Water Polo
56 Weight Lifting
58 Wrestling

99 Other: ________

B. LEVEL ☐

1 Varsity
2 Junior Varsity
3 Freshman
4 Intramural
5 Club
6 Phys. Ed., Grad. League, other organized
7 Informal

C. SEX OF TEAM ☐

1 All Men
2 All Women
3 Coed

6. ACTIVITY ☐☐

00 Not Applicable
02 Batting
03 Being Blocked
04 Being Tackled
06 Blocking
08 Catching
10 Checking
12 Dismounting
14 Diving
16 Dribbling
18 Heading
20 Hurdling
22 Jumping
23 Kicked
24 Kicking
26 Lifting
28 Lunging
30 Mounting
32 Retreating
34 Riding
36 Rowing
38 Running
40 Shooting
42 Sliding
44 Skating
46 Sprinting
48 Swimming
50 Swinging
52 Tackling
54 Throwing
56 Turning
58 Twisting
60 Vaulting
62 Wrestling
99 Other: ________

7. SURFACE

A. TYPE ☐

0 Not Applicable
1 Artificial Turf/Surface
2 Asphalt
3 Clay
4 Concrete
5 Dirt or Cinder
6 Grass
7 Mat
8 Wood
9 Other: ________

B. CONDITION ☐

0 Not Applicable
1 Normal
2 Wet or Slippery
3 Muddy
4 Icy
5 Baked, Hard or Frozen
6 Snow-covered
7 Irregular, Poor Condition or Repairs

FOR OFFICE USE ONLY

8. LOST PRACTICE/COMPETITION TIME

A. ESTIMATED ☐

0 None
1 1 day
2 2-4 days
3 5-7 days
4 1-2 weeks
5 2-4 weeks
6 >1 month

B. DISABILITY LIST

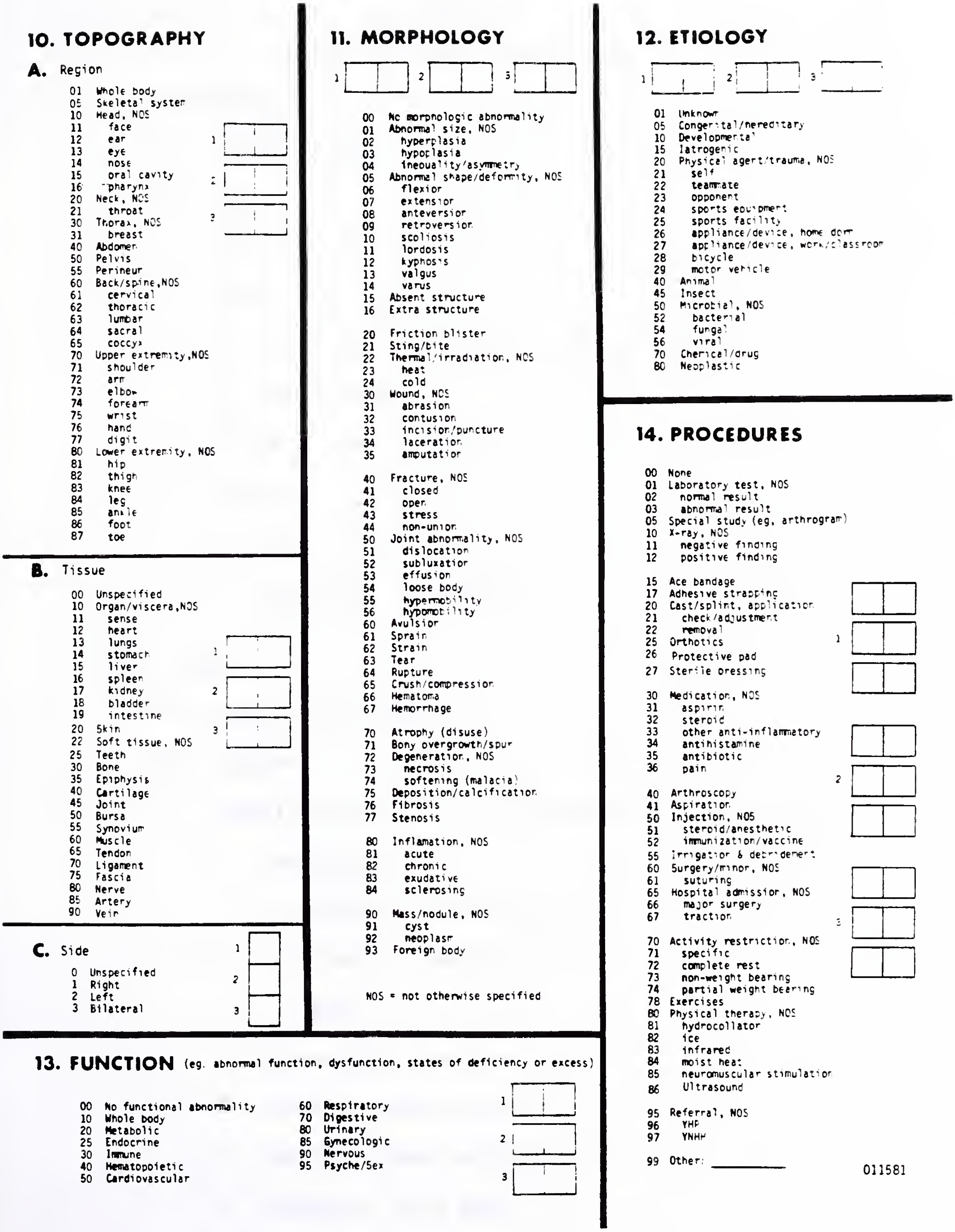
☐ ADD ON ☐ TAKE OFF

9. DIAGNOSIS (use as one continuous line)

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Figure 1. Coding form, front side (smaller than actual size).



10. TOPOGRAPHY

A. Region

- 01 Whole body
- 05 Skeletal system
- 10 Head, NOS
  - 11 face
  - 12 ear
  - 13 eye
  - 14 nose
  - 15 oral cavity
  - 16 pharynx
- 20 Neck, NOS
  - 21 throat
- 30 Thorax, NOS
  - 31 breast
- 40 Abdomen
- 50 Pelvis
- 55 Perineum
- 60 Back/spine,NOS
  - 61 cervical
  - 62 thoracic
  - 63 lumbar
  - 64 sacral
  - 65 coccyx
- 70 Upper extremity,NOS
  - 71 shoulder
  - 72 arm
  - 73 elbow
  - 74 forearm
  - 75 wrist
  - 76 hand
  - 77 digit
- 80 Lower extremity, NOS
  - 81 hip
  - 82 thigh
  - 83 knee
  - 84 leg
  - 85 ankle
  - 86 foot
  - 87 toe

1 ☐☐
2 ☐☐
3 ☐☐

B. Tissue

- 00 Unspecified
- 10 Organ/viscera,NOS
  - 11 sense
  - 12 heart
  - 13 lungs
  - 14 stomach
  - 15 liver
  - 16 spleen
  - 17 kidney
  - 18 bladder
  - 19 intestine
- 20 Skin
- 22 Soft tissue, NOS
- 25 Teeth
- 30 Bone
- 35 Epiphysis
- 40 Cartilage
- 45 Joint
- 50 Bursa
- 55 Synovium
- 60 Muscle
- 65 Tendon
- 70 Ligament
- 75 Fascia
- 80 Nerve
- 85 Artery
- 90 Vein

1 ☐☐
2 ☐☐
3 ☐☐

C. Side

- 0 Unspecified
- 1 Right
- 2 Left
- 3 Bilateral

1 ☐
2 ☐
3 ☐

11. MORPHOLOGY

1 ☐☐ 2 ☐☐ 3 ☐☐

- 00 No morphologic abnormality
- 01 Abnormal size, NOS
  - 02 hyperplasia
  - 03 hypoplasia
  - 04 inequality/asymmetry
- 05 Abnormal shape/deformity, NOS
  - 06 flexion
  - 07 extension
  - 08 anteversion
  - 09 retroversion
  - 10 scoliosis
  - 11 lordosis
  - 12 kyphosis
  - 13 valgus
  - 14 varus
- 15 Absent structure
- 16 Extra structure

- 20 Friction blister
- 21 Sting/bite
- 22 Thermal/irradiation, NOS
  - 23 heat
  - 24 cold
- 30 Wound, NOS
  - 31 abrasion
  - 32 contusion
  - 33 incision/puncture
  - 34 laceration
  - 35 amputation

- 40 Fracture, NOS
  - 41 closed
  - 42 open
  - 43 stress
  - 44 non-union
- 50 Joint abnormality, NOS
  - 51 dislocation
  - 52 subluxation
  - 53 effusion
  - 54 loose body
  - 55 hypermobility
  - 56 hypomobility
- 60 Avulsion
- 61 Sprain
- 62 Strain
- 63 Tear
- 64 Rupture
- 65 Crush/compression
- 66 Hematoma
- 67 Hemorrhage

- 70 Atrophy (disuse)
- 71 Bony overgrowth/spur
- 72 Degeneration, NOS
  - 73 necrosis
  - 74 softening (malacia)
- 75 Deposition/calcification
- 76 Fibrosis
- 77 Stenosis

- 80 Inflamation, NOS
  - 81 acute
  - 82 chronic
  - 83 exudative
  - 84 sclerosing

- 90 Mass/nodule, NOS
  - 91 cyst
  - 92 neoplasm
- 93 Foreign body

NOS = not otherwise specified

12. ETIOLOGY

1 ☐☐ 2 ☐☐ 3 ☐☐

- 01 Unknown
- 05 Congenital/hereditary
- 10 Developmental
- 15 Iatrogenic
- 20 Physical agent/trauma, NOS
  - 21 self
  - 22 teammate
  - 23 opponent
  - 24 sports equipment
  - 25 sports facility
  - 26 appliance/device, home dorm
  - 27 appliance/device, work/classroom
  - 28 bicycle
  - 29 motor vehicle
- 40 Animal
- 45 Insect
- 50 Microbial, NOS
  - 52 bacterial
  - 54 fungal
  - 56 viral
- 70 Chemical/drug
- 80 Neoplastic

13. FUNCTION (eg. abnormal function, dysfunction, states of deficiency or excess)

- 00 No functional abnormality
- 10 Whole body
- 20 Metabolic
- 25 Endocrine
- 30 Immune
- 40 Hematopoietic
- 50 Cardiovascular
- 60 Respiratory
- 70 Digestive
- 80 Urinary
- 85 Gynecologic
- 90 Nervous
- 95 Psyche/Sex

1 ☐☐
2 ☐☐
3 ☐☐

14. PROCEDURES

- 00 None
- 01 Laboratory test, NOS
  - 02 normal result
  - 03 abnormal result
- 05 Special study (eg, arthrogram)
- 10 X-ray, NOS
  - 11 negative finding
  - 12 positive finding

- 15 Ace bandage
- 17 Adhesive strapping
- 20 Cast/splint, application
  - 21 check/adjustment
  - 22 removal
- 25 Orthotics
- 26 Protective pad
- 27 Sterile dressing

- 30 Medication, NOS
  - 31 aspirin
  - 32 steroid
  - 33 other anti-inflammatory
  - 34 antihistamine
  - 35 antibiotic
  - 36 pain

- 40 Arthroscopy
- 41 Aspiration
- 50 Injection, NOS
  - 51 steroid/anesthetic
  - 52 immunization/vaccine
- 55 Irrigation & debridement
- 60 Surgery/minor, NOS
  - 61 suturing
- 65 Hospital admission, NOS
  - 66 major surgery
  - 67 traction

- 70 Activity restriction, NOS
  - 71 specific
  - 72 complete rest
  - 73 non-weight bearing
  - 74 partial weight bearing
- 78 Exercises
- 80 Physical therapy, NOS
  - 81 hydrocollator
  - 82 ice
  - 83 infrared
  - 84 moist heat
  - 85 neuromuscular stimulation
  - 86 Ultrasound

- 95 Referral, NOS
  - 96 YHP
  - 97 YNHH

99 Other: __________

1 ☐☐ ☐☐ ☐☐
2 ☐☐ ☐☐ ☐☐
3 ☐☐ ☐☐ ☐☐

011581

Figure 2. Coding form, back side (smaller than actual size).

Table 3

Data Collected on Coding Form

- I. Demographic
  - A. Identification
  - B. Date
  - C. Occasion (see Table 4)
  - D. Sport (see Table 5)
    - 1. Level of competition (see Table 6)
    - 2. Sex of team
  - E. Activity (see Table 7)
  - F. Surface
    - 1. Type (see Table 8)
    - 2. Condition (see Table 9)

- II. Injury
  - A. Nature (see Table 10)
  - B. Diagnosis
  - C. Classification (up to three codes in each category)
    - 1. Topography
      - a. Region (see Table 11)
      - b. Tissue (see Table 12)
      - c. Side
    - 2. Morphology (see Table 13)
    - 3. Etiology (see Table 14)
    - 4. Function (see Table 15)
    - 5. Procedure (see Table 17)
  - D. Severity
    - 1. Estimated lost practice/competition time (see Table 18)
    - 2. Disability list: add on/take off

or trainer seeing the athlete reviews these selection. For illustrative purposes, consider the following case: Jane Smith, a star forward on the women's varsity soccer squad, is attempting a shot on goal early in the second half of play when she is blocked by a defender and knocked to the ground. She lands directly on her right knee on a particularly hard section of the grass field. She is found to have a fractured patella and a non-specific ligamentous injury to the knee. The following data would be collected:

(1) Date: Day, month, and year of the visit is collected.

(2) Occasion (Table 4): Problems are divided into acute (either sports related or not) and non-acute (mainly medical problems). Among sports related injuries, this parameter distinguishes between injuries in various stages of practice and competition. For our example, the term "competition--3rd quarter" would best describe this injury occurring early in the second half of play.

(3) Sport (Table 5): A list of approximately thirty sports (with room for expansion) is provided. For Jane Smith the term "soccer" would be coded.

(4) Level (Table 6): A determination of whether the injury occurred at the intercollegiate, intramural, or club level is recorded. In our example the level would be "varsity".

(5) Sex of team: All men, all women, or coed. For our example, one would code "all women".

(6) Activity (Table 7): In order to have an indication of what the athlete was doing when the injury occurred, a selection of over thirty adjectives describing various activities is provided. Jane Smith would be likely to respond that she was "being blocked" although

Table 4 *

Occasion of Injury Categories

- Not Sudden Onset [nonacute]
- Sports Related, NOS [sprt,nos]
  - practice
  - scrimmage [scrimmag]
  - competition, NOS [comp,nos]
    - early--1st quarter/period [comp.1st]
    - middle-2nd quarter/period [comp.2nd]
    - late --3rd quarter/period [comp.3rd]
      - --4th quarter [comp.4th]
  - locker/shower/training area [locker]
  - team travel [travel]
  - training during off-season [training]
- Not Sports Related [not sprt]

Table 5

Sports

- Archery
- Baseball
- Basketball [basketb.]
- Bowling
- Crew
- Cross Country [css-coun]
- Curling
- Fencing
- Field Hockey [fld.hock]
- Football, Tackle [footb,tk]
- Football, Other [footb,ot]
- Golf
- Gymnastics [gymnast.]
- Ice Hockey [ice hock]
- Judo
- Lacrosse
- Rodeo
- Rugby
- Skiing
- Soccer
- Softball
- Squash
- Swimming/Diving [swim/div]
- Tennis
- Track and Field [trk&fld]
- Volleyball [volleyb.]
- Water Polo [wat. polo]
- Weight Lifting [wt. lift]
- Wrestling [wrestlin]
- Other

---

* Terms in brackets are abbreviations used by computer for output. NOS = not otherwise specified.

Table 6

Level of Competition Categories

Varsity [V]
Junior Varsity [JV]
Freshman [F]
Intramural [IM]
Club [CL]
Phys. Ed., Grad. League, [PE]
other organized
Informal [IN]

Table 7

Activity Terms

Not Applicable [n/a]
Batting
Being Blocked [blocked]
Being Tackled [tackled]
Blocking [block-]
Catching [catch-]
Checking [check-]
Dismounting [dismoun]
Diving
Dribbling [dribbl-]
Heading
Hurdling
Jumping
Kicked
Kicking
Lifting
Lunging
Mounting [mount-]
Retreating [retreat]
Riding
Rowing
Running
Shooting [shoot-]
Sliding
Skating
Sprinting [sprint-]
Swimming [swim-]
Swinging [swing-]
Tackling [tacklin]
Throwing [throw-]
Turing
Twisting [twist-]
Vaulting [vault-]
Wrestling [wrestle]
Other

she might also enter "being tackled" or "shooting".

(7) Surface type (Table 8): A choice of several common types of playing surfaces applicable to all sports is provided. For our example the term "grass" would be chosen.

(8) Surface condition (Table 9): General terms describing field conditions are listed. Since Jane's injury occurred on a hard portion of the field, the term "baked, hard, or frozen" would be appropriate.

A description of the injury itself as well as severity and management is also obtained. The physician or trainer examining the patient provides this information (except for the first item which is provided by the athlete) and also enters his or her own personal identification code. The following is collected:

(1) Nature (Table 10): Since visits to an athletic medicine clinic, rather than unique injuries, are being recorded, this category is used to differentiate amongst new injuries, recurrences, and follow-up visits. For Jane Smith, with no history of problems with her knee, this would be coded as a "new injury or illness".

(2) Diagnosis: A written, free form descriptive diagnosis of less than thirty characters is supplied. This provides additional detail when retrieving injuries. For our example, the physician might enter "FX PATELLA & KNEE SPRAIN".

(3) Topography--Region (Table 11): The Topography axis of SNOMED has been separated into three separate axes to allow for the increased anatomical descriptive requirements of orthopaedic problems: Region, Tissue, and Side. All terms are actually subsets of the standard Topography axis. Region provides a description of the part of the body affected. For this category and the other injury clasification axes as

Table 8

Surface Types

Not Applicable [n/a]
Artificial Turf/Surface [artif]
Asphalt [aspht]
Clay
Concrete [concr]
Dirt or Cinder [dirt]
Grass
Mat
Wood
Other

Table 9

Surface Condition Terms

Not Applicable [n/a]
Normal [norml]
Wet or Slippery [wet]
Muddy
Icy
Baked, Hard or Frozen [hard]
Snow-covered [snow]
Irregular, Poor Condition or Repairs [irreg]

Table 10

Nature of Visit Categories

New injury or illness, first visit [new, 1st]

Recurrence:
- Original problem this season [recur-s]
- Original problem prior to season but within last year [recur<1]
- Original problem more than 1 year ago [recur>1]

Follow-up visit [fol/up]

Table 11

Topography Region Terms

- Whole body [body]
- Skeletal system [skeletal]
- Head, NOS
  - face
  - ear
  - eye
  - nose
  - oral cavity [mouth]
  - pharynx
- Neck, NOS
  - throat
- Thorax, NOS
  - breast
- Abdomen
- Pelvis
- Perineum
- Back/spine, NOS [back,nos]
  - cervical [c-spine]
  - thoracic [t-spine]
  - lumbar [l-spine]
  - sacral
  - coccyx
- Upper extremity, NOS [up extr]
  - shoulder
  - arm
  - elbow
  - forearm
  - wrist
  - hand
  - digit
- Lower extremity, NOS [low.extr]
  - hip
  - thigh
  - knee
  - leg
  - ankle
  - foot
  - toe

Table 12

Topography Tissue Terms

- Unspecified [unspec.]
- Organ/viscera, NOS [viscera]
  - sense [snse org]
  - heart
  - lungs
  - stomach
  - liver
  - spleen
  - kidney
  - bladder
  - intestine [intestin]
- Skin
- Soft tissue, NOS [soft,nos]
- Teeth
- Bone
- Epiphysis [epiphys]
- Cartilage [cartilag]
- Joint
- Bursa
- Synovium
- Muscle
- Tendon
- Ligament
- Fascia
- Nerve
- Artery
- Vein
- Other

many as three terms can be specified. For our example, the only region that need be entered is "knee". In other cases, for example, a contusion to the lower thigh and knee area, more than one region could be entered.

(4) Topography--Tissue (Table 12): A list of organs and tissues is provided to delineate the anatomical location of the injury. In our example, Jane's injury includes components affecting "bone" (her fracture), "ligament" (her sprain), and also "joint" as there may be some degree of effusion.

(5) Topography--Side: Left, right, or bilateral is specified. Jane Smith's injury is to her "right" side.

(6) Morphology (Table 13): Terms are chosen to provide descriptions of the pathology found in all injuries routinely encountered. The terms are grouped roughly by etiology: developmental, congenital, surface trauma, deep trauma, degenerative, and inflammatory. For our example, we arrange our choices to correspond to those chosen under Tissue. Jane's injury was composed of a "fracture--closed," a "sprain," and a "joint effusion".

(7) Etiology (Table 14): A choice of terms describing cause, including a subdivision of trauma into specific sports related categories (such as opponent, teammate, equipment) is provided. In our example, the injury would be classified as "physical agent/trauma, opponent" as she was knocked to the ground, and also "physical agent/trauma, sports facility" if it were felt that striking the hard playing surface contributed to the injury.

(8) Function (Table 15): To describe problems without clear morphologic (anatomic) abnormalities, a list of body systems in which physiologic (functional) abnormalities can occur is provided. These

Table 13

Morphology Terms

- No morphologic abnormality [not abnl]
- Abnormal size, NOS [abnl size]
  - hyperplasia [hyperplas.]
  - hypoplasia
  - inequality/asymmetry [asymmetry]
- Abnormal shape/deformity, NOS [abnl shape]
  - flexion
  - extension
  - anteversion [antevers.]
  - retroversion [retrovers.]
  - scoliosis
  - lordosis
  - kyphosis
  - valgus
  - varus
- Absent structure [absnt strc]
- Extra structure [xtra strct]

- Friction Blister [frict.blist]
- Sting/bite
- Thermal/irradiation, NOS [thrm/irrad]
  - heat
  - cold
- Wound, NOS
  - abrasion
  - contusion
  - incision/puncture [incis/punc]
  - laceration
  - amputation

- Fracture, NOS [fract,nos]
  - closed [fract,clsd]
  - open [fract,open]
  - stress [frac,stress]
  - non-union

- Joint abnormality, NOS [joint abnl]
  - dislocation [dislocated]
  - subluxation [subluxed]
  - effusion [j-effusion]
  - loose body
  - hypermobility [j,hypermob]
  - hypomobility [j,hypomob.]
- Avulsion
- Sprain
- Strain
- Tear
- Rupture
- Crush/compression [crush/comp]
- Hematoma
- Hemorrhage

- Atrophy, disuse
- Bony overgrowth/spur [bone spur]
- Degeneration, NOS [degen,nos]
  - necrosis
  - softening [malacia]
- Deposition/calcification [depos/calc]
- Fibrosis
- Stenosis
- Inflammation, NOS [inflam,nos]
  - acute [inflam,acu]
  - chronic [inflam,chr]
  - exudative [inflm,exud]
  - sclerosing [in,scleros]

- Mass/nodule, NOS [mass/nodul]
  - cyst
  - neoplasm
- Foreign body [forgn body]

Table 14

Etiology Terms

- Unknown
- Congenital/hereditary [congenital]
- Developmental [developmnt]
- Iatrogenic
- Physical agent/trauma, NOS [trauma, nos]
  - self [traum, nos]
  - teammate [t,teammate]
  - opponent [t,opponent]
  - sports equipment [t,sp.equip]
  - sports facility [t,sp.facil]
  - appliance/device, home/dorm [traum,home]
  - appliance/device, work/classroom [traum,work]
  - bicycle [t,bicycle]
  - motor vehicle [t,vehicle]
- Animal
- Insect
- Microbial, NOS [microb,nos]
  - bacterial
  - fungal
  - viral
- Chemical/drug [chem/drug]
- Neoplastic

Table 15

Function Categories

No functional abnormality [none]
Whole body eg. dehydration, heat exhaustion, stress [whole]
Metabolic eg. electrolytes, vitamins, bone turnover [metab]
Endocrine eg. hypothyroid [endoc]
Immune eg. anaphylaxis, allergy [immun]
Hematopoietic eg. anemia, bleeding disorders [hemat]
Cardiovascular eg. high blood pressure, murmur [card]
Respiratory eg. cough, dyspnea, wheezing [resp]
Digestive eg. anorexia, nausea, vomiting, diarrhea [diges]
Urinary eg. dysuria [urin]
Gynecologic eg. amenorrhea, dysmenorrhea, menorrhagia [gynec]
Nervous eg. motor, sensory or sense organ disorders, syncope, seizure [nerv]
Psyche/Sex eg. addiction, adjustment, anxiety, depression, phobia [psych]

Table 16

Examples of Expanded Functional Terms

- Whole body:
  - Stress
  - Exhaustion
  - Fatigue
  - Body weight
  - Dehydration
  - Body temperature
  - Exposure
  - Pain
- Digestive:
  - Appetite
  - Thirst
  - Dyspepsia
  - Bloating
  - Nausea
  - Vomiting
  - Diarrhea
  - Constipation

Table 17

Procedure Terms

- None
- Laboratory test, NOS [lab test]
  - normal result [lab, nl]
  - abnormal result [lab,abnl]
- Special study [spec.std]
- X-ray, NOS [x-ray]
  - negative finding [xray,neg]
  - positive finding [xray,pos]

- Ace bandage [ace]
- Adhesive strapping [ad.strap]
- Cast/splint, application [cast, on]
  - check/adjustment [cast,adj]
  - removal [cast,off]
- Orthotics
- Protective padding [padding]
- Sterile dressing [ster.drs]

- Medication, NOS [drug,nos]
  - aspirin
  - steroid
  - other anti-inflammatory [a-inflam]
  - antihistamine [antihist]
  - antibiotic [antibiot]
  - pain [pain med]

- Arthroscopy [arthrosc]
- Aspiration [aspirate]

- Injection, NOS [inject]
  - steroid/anesthetis [inject-s]
  - immunization/vaccine [immuniz]
- Irrigation & debridement [i&d]
- Surgery/minor, NOS [surg,min]
  - suturing
- Hospital admission, NOS [hosp adm]
  - major surgery [maj. surg]
  - traction

- Activity restriction, NOS [act.rstn]
  - specific [act.r,sp]
  - complete rest [rest,cpt]
  - non-weight bearing [non-wt.]
  - partial weight bearing [part.wt.]
- Exercises
- Physical therapy, NOS [p.t. nos]
  - hydrocollator [hydrocol]
  - ice
  - infrared
  - moist heat [mst. heat]
  - neuromuscular stimulation [n-m stim]
  - ultrasound [ultrasnd]

- Referral, NOS
  - YHP [ref-yhp]
  - YNHH [ref-ynhh]

- Other

tend to be mainly medical problems. For the purpose of most injury studies these general terms will suffice, but each body system can be expanded to provide a variety of functional disorders (Table 16). Jane Smith's injury had no associated functional abnormality so "none" would be entered. If, for example, she developed a hemarthrosis found to be secondary to an underlying bleeding diathesis the term "hematopoietic" would be entered.

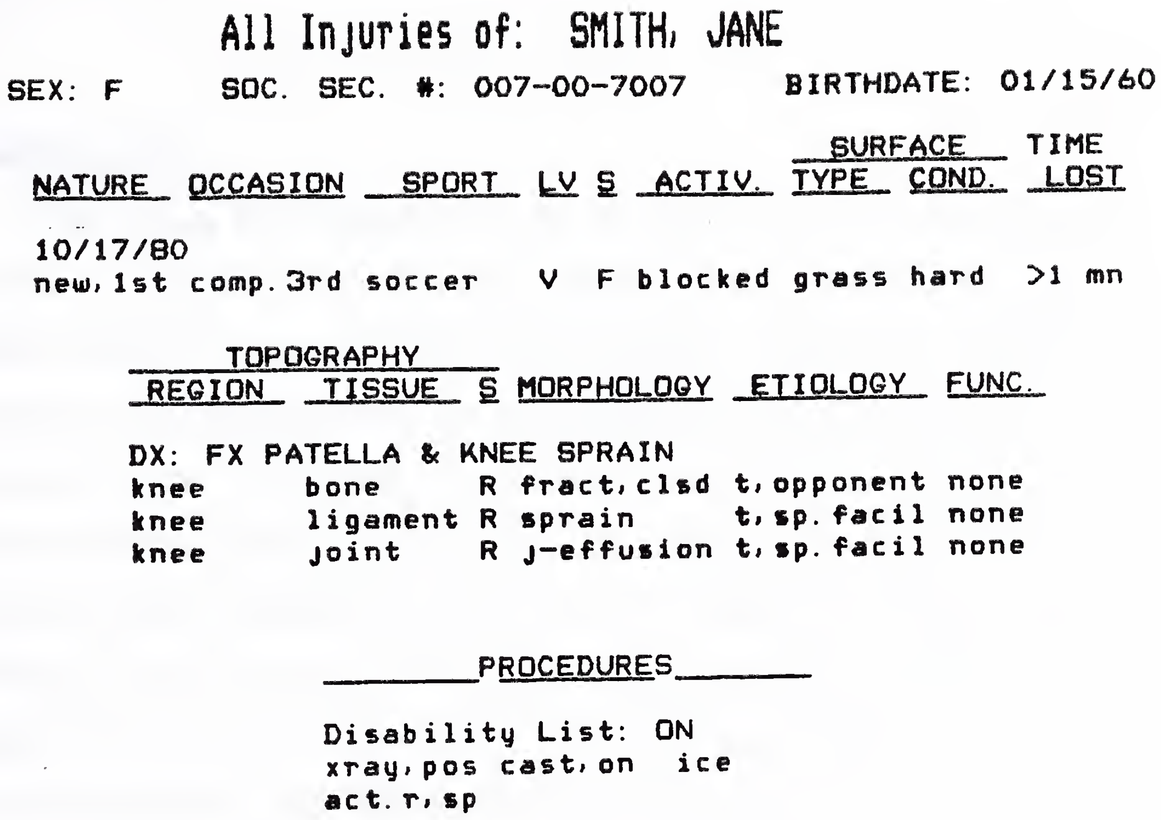
(9) Procedure (Table 17): This category provides a choice of common diagnostis and therapeutic procedures used in management of athletic injuries. When injuries are retrieved this data can shed additional light on the severity by revealing what management steps (e.g., major surgery, hospital admission) were necessary. A total of nine terms can be specified. For Jane, these might include "x-ray, positive," "cast/splint application," "ice," and "specific activity restriction".

(10) Severity: An estimate of the amount of lost practice and competition time is obtained by selection of the appropriate time range (Table 18). The Department of Athletic Medicine employs a "disability list" to regulate the participation of injured or ill athletes. A person

Table 18

Lost Practice/Competition Time Ranges

None	
1 day	
2-4 days	[2-4 d]
5-7 days	[5-7 d]
1-2 weeks	[1-2wk]
2-4 weeks	[2-4wk]
>1 month	[>1 mn]
Permanent paralysis	[PARAL]
Fatal	



```
              All Injuries of:  SMITH, JANE
  SEX: F      SOC. SEC. #: 007-00-7007     BIRTHDATE: 01/15/60
                                                 SURFACE    TIME
   NATURE  OCCASION   SPORT  LV S  ACTIV.  TYPE  COND.   LOST

   10/17/80
   new, 1st comp. 3rd soccer   V  F blocked grass hard  >1 mn

              TOPOGRAPHY
          REGION   TISSUE  S MORPHOLOGY  ETIOLOGY  FUNC.

          DX: FX PATELLA & KNEE SPRAIN
          knee     bone      R fract, clsd t, opponent none
          knee     ligament  R sprain      t, sp. facil none
          knee     joint     R j-effusion  t, sp. facil none


                      PROCEDURES

                   Disability List: ON
                   xray, pos cast, on  ice
                   act. r, sp
```

Figure 3. Computer summary of sample injury.

placed on the list is not allowed to engage in any sport until medical clearance is obtained at a follow-up examination. Thus, if the athlete is being placed on or taken off the disability list this is recorded. For our example, the time range would be "greater than one month" and Jane would most probably be placed on the disability list. The computer print-out summarizing Jane's injury is shown in Figure 3.

It should be noted that the Disease axis of SNOMED is omitted as it is composed of complex, non-orthopaedic disease entities. If necessary, most of these can be listed in the free form diagnosis and then coded as a functional abnormality under the appropriate body system.

Implementation

The coding form (Figures 1 and 2) is distributed to each student athlete being seen in the Athletic Medicine Clinic of the University Health Service by the reception desk personnel. He or she is asked to complete the identification and demographic data sections. The form is returned to the receptionist and is used to call for the student's medical record and then announce the patient. The trainer or physician seeing the athlete enters a diagnosis, selects terms to describe the injury and its severity, and also reviews the codes that the student has selected. The completed forms are reviewed daily along with the medical records, x-rays, and lab reports by the Director of Athletic Medicine to insure accuracy. Finally, forms are entered into the computer by an administrative/ research assistant.

Data Handling

A "Basic Four" System 730 computer was used for data entry, storage, and retrieval. This is an on-line multitasking system with partitioned memory and 150 megabytes of disc storage with an average access time of thirty milliseconds. The system is used primarily for financial management and subscriber services of the Yale Health Plan. The operating system supports a version of the programming language Basic known as Business Basic Level 3. Software has been designed to assist all stages of data storage and retrieval. All tasks are performed via an interactive video display terminal (VDT). Output is printed on standard sixteen inch (132 character line) paper by a three hundred lines per

minute printer.

To insure against loss of data in the event of computer failure, multiple copies are make. Each disc is copied in its entirety to one of two backup discs at the end of each day, resulting in one exact copy and a one day old copy. Copies of each disc to magnetic tape for off site storage are made weekly. In addition, magnetic tape copies of only athletic injury data and programs are made every two weeks.

The "disc" is a magnetic storage device allowing almost instantaneous random access to data. This is the primary storage media for both programs (software) and data files. Data files can be used by any number of users at the same time and may contain up to 2^{23} (8,388,608) records (entries). The basic file type used is called a "direct" file. Each entry or "record" is composed of an identifier or "key" plus the actual data. The computer orders the keys in numerical/alphabetical order. Although the computer stores the keys and data in physically separate locations; this file allows the selective retrieval of any data entry. An analogy would be to a book of data where the entry is made on the last blank page and the book's index is updated immediately. This index is actually also present in the computer and is known as the Scatter Index Table and the Key Area, but these are transparent even to the programmer.

The "sort" file is a variation of the direct file in that it contains keys only — there is no data area. It is used primarily as a cross reference file, to enable the ordering of data entries in some other sequence than the keys used for the direct file.

The athlete file (Table 19), with a single alphabetically arranged entry for each athlete, contains identification data as well as a flag

Table 19

Athlete File

Name: DSWATH Type: Direct

Keysize: 20 characters
Key = Last name [first 10 characters] + First name [first 4 char.] + Social security number [last 6 digits]

Data size: 64 bytes per record
Data [number of characters in brackets] (variable name in parentheses)
(1) Last name [12 characters, padded with blanks] (N9$)
(2) First name [10 char., padded with blanks] (N3$)
(3) Middle initial [2] (N6$)
(4) Sex: "M" or "F" (X$)
(5) Number of injuries recorded [3 digits; <1000] (I)
(6) Social security number [9] (S$)
(7) Birthdate [6] (B$)
(8) Injury number if on disab., "000" if off [3] (F2$)
(9) Date on disability, format: mmddyy [6] (F3$)

Table 20

Social Security Number to Name Cross Reference File

Name: DSWCXA Type: Sort

Keysize: 23 characters
Key = Social security number [9 char.] + Last name [first 10 char.] + First name [first 4 char.]

---

to indicate whether the athlete is on the disability list. Each athlete has a unique identification number; for this purpose the social security number is used. A cross reference file (Table 20) ordered by social security number is used to enable an athlete to be looked up by number as well as name and to insure that no duplicate numbers are entered.

Each injury is stored in the main injury file (Table 21) and is identified by a unique "injury reference number" composed of the athlete's social security number plus a three digit suffix. This allows the storage

Table 21

Main Injury File

Name: DSWIN1 Type: Direct

Keysize: 12 characters
Key = Injury reference number
= Soc. sec. # [9 digits] + (1000 minus injury number) [3 digits]

Data size: 100 bytes per record
Data [# characters] (variable name):
- (1) Number of components, ≤ 3 (N)
- (2) Date, format: yymmdd [6] (D1$)
- (3) Demographic codes: [18] (Z$) concatenation of:
  - (a) Nature [1 + blank]
  - (b) Occasion [2]
  - (c) Sport [2]
  - (d) Level [1 + blank]
  - (e) Sex [1 + blank]
  - (f) Activity [2]
  - (g) Surface type [1 + blank]
  - (h) Surface condition [1 + blank]
  - (i) Estimated time lost [1 + blank]
- (4) Diagnosis [30] (D$)
- (5) Injury classification codes [18] (C$) concatenation of:
  - (a) Region [2]
  - (b) Tissue [2]
  - (c) Side [1 + blank]
  - (d) Morphology [2]
  - (e) Etiology [2]
  - (f) Function [2]
  - (g) Procedure 1 [2]
  - (h) Procedure 2 [2]
  - (i) Procedure 3 [2]
- (6) Number of days on disability [3] (L9$)
- (7) Injury reference number [12] (J$)

Table 22

Accessory Injury File

Name: DSWIN2 Type: Direct

Keysize: 13 characters
Key = Injury reference number (see Table 21) + Component number ("2" or "3")

Data size: 33 bytes per record
Data [# characters] (variable name):
- (1) Injury classification codes [18] (C$)
  See Table 21, item 3
- (2) Injury reference number + component number [13]

of a maximum of 1000 injury visits per athlete. The injury record includes: (1) the date; (2) demographic data, which is stored as an eighteen character string resulting from the concatenation of the two digit (or one digit plus blank) codes; (3) the written diagnosis; (4) the number of days on disability for this injury; and (5) the SNOMED injury classifications (the first term listed for each axis, i.e., the first "component"). Since standard SNOMED codes contain four to five digits and a subset of less than one hundred codes per axis is being employed, it is possible to save space by using two digit codes. Conversion to SNOMED codes can be accomplished if necessary. The injury classification data is stored as an eighteen character string composed of the concatenation of the two digit codes. Up to two additional components of the injury classification are stored as separate records in the accessory injury file (Table 22). A separate file contains an entry, sorted by sport and sex, and the diagnosis for each athlete placed on the disability list (Table 23). This allows easy generation of a disability list arranged by team.

Although it is possible to retrieve specified injuries by searching through all records in the injury file, it is far faster and more efficient tp create cross reference files for search purposes. The main cross reference file (Table 24) is a sort file whose keys are composed of a prefix ("1" through "9" amd "A" through "G") to identify the demographic or classification category, the two digit code, and the injury reference number. Thus, for example, to retrieve all injuries coded as involving the knee, one would look up in the file for all entries beginning with "A83" ("A" being the prefix denoting region, "83" being the code for knee). Another cross reference file is for retrieving data by date

Table 23

Disability List File

Name: DSWDIS Type: Direct

Keysize: 17 characters
Key = Sport code [2 digits] + Sex ["M" or "F"] + Level code [2] + Injury reference number [12]

Data size: 36 bytes per record
Data: Diagnosis [30 characters] (variable name: D$)

Table 24

Main Cross Reference File

Name: DSWCXB Type: Sort

Keysize: 15 characters
Key = Prefix [1 character] + Code [2] + Injury reference number [12]
Prefixes:
1 = Nature
2 = Occasion
3 = Sport
4 = Level of competition
5 = Sex of team
6 = Activity
7 = Surface type
8 = Surface condition
9 = Estimated time lost

A = Region
B = Tissue
C = Side
D = Morphology
E = Etiology
F = Function
G = Procedure

If the prefix is a lower case letter, the two digits following represent the number of days on disability:
a = no modification to disability days
b = disability days plus 100 days
c = 200
d = 300
...through...
j = disability days plus 900 days

Table 25

Date Cross Reference File

Name: DSWCXD Type: Sort

Keysize: 18 characters
Key = Date, format yymmdd [6] + Injury reference number [12]

Table 26

Output File

Name: DSWOUT Type: Direct

Keysize: 3 characters
Key = Prefix (see Table 23) [1 character] + Code [2]

Data size: 11 bytes per record
Data: Abbreviation for term represented by code [10]
If the code is "**" the output characters represent
the title for that category.

(Table 25); this allows review of injury visits on a single date or range of dates.

When reviewing injuries it is most convenient to have the actual terms listed, even if abbreviated, rather than only the codes. In order to accomplish this an output file (Table 26) which allows translation of codes to descriptive terms is employed. It would also be possible to use several files that could each translate codes into a different foreign language. This is an extremely powerful feature: it allows storage of athletic injuries in a universal medium that could then be transposed into any language necessary, permitting a world-wide discourse and investigation of athletic injuries.

RESULTS

System Operation

To operate the Yale Athletic Medicine Reporting System (YAMRS) the video display terminal (VDT) must be in the console mode. This is identifiable by the presence on the screen of the word READY followed by a greater-than symbol and cursor (solid rectangle) appearing on the next line:

```
READY
> █
```

The position of the cursor represents the position at which a number or letter will appear on the screen if entered on the VDT keyboard. Entering the words RUN "SPORTS" (followed by pressing the carriage return/enter [CR] key, necessary to signal that information has been entered) begins the program. To prevent unauthorized access to what are essentially confidential medical records, a correct password must be typed before entering the YAMRS system. A selection screen is displayed (Table 27) which lists the various phases of input, output, and system upkeep (utilities). The desired keyword is entered in order to proceed.

It should be noted that when entering this keyword and during certain other situations the CR key need not be depressed: The computer automatically senses the correct number of characters and continues processing. Occasionally it is necessary to press one of a special group of keys known as motor bars (MB) and labelled I, II, III, IV. These keys are located at the far right of the keyboard and are used to control branching within the system. The MB IV key is used to exit from any stage of the system and pressing it several times will return processing to the selection screen.

Table 27

Mode Selection Screen

Keywords	Mode Functions
ATHL	Inputs, displays, and corrects athlete and injury data. Prints injuries for any single athlete.
OTPT	Searches for and prints injuries by any combination of codes requested. Tabulates types of entries in each category.
LIST	Prints disability list, athlete roster, and tabulates types of injuries in any single category.
UTIL	System utility selector: update output characters, examine keys of files.

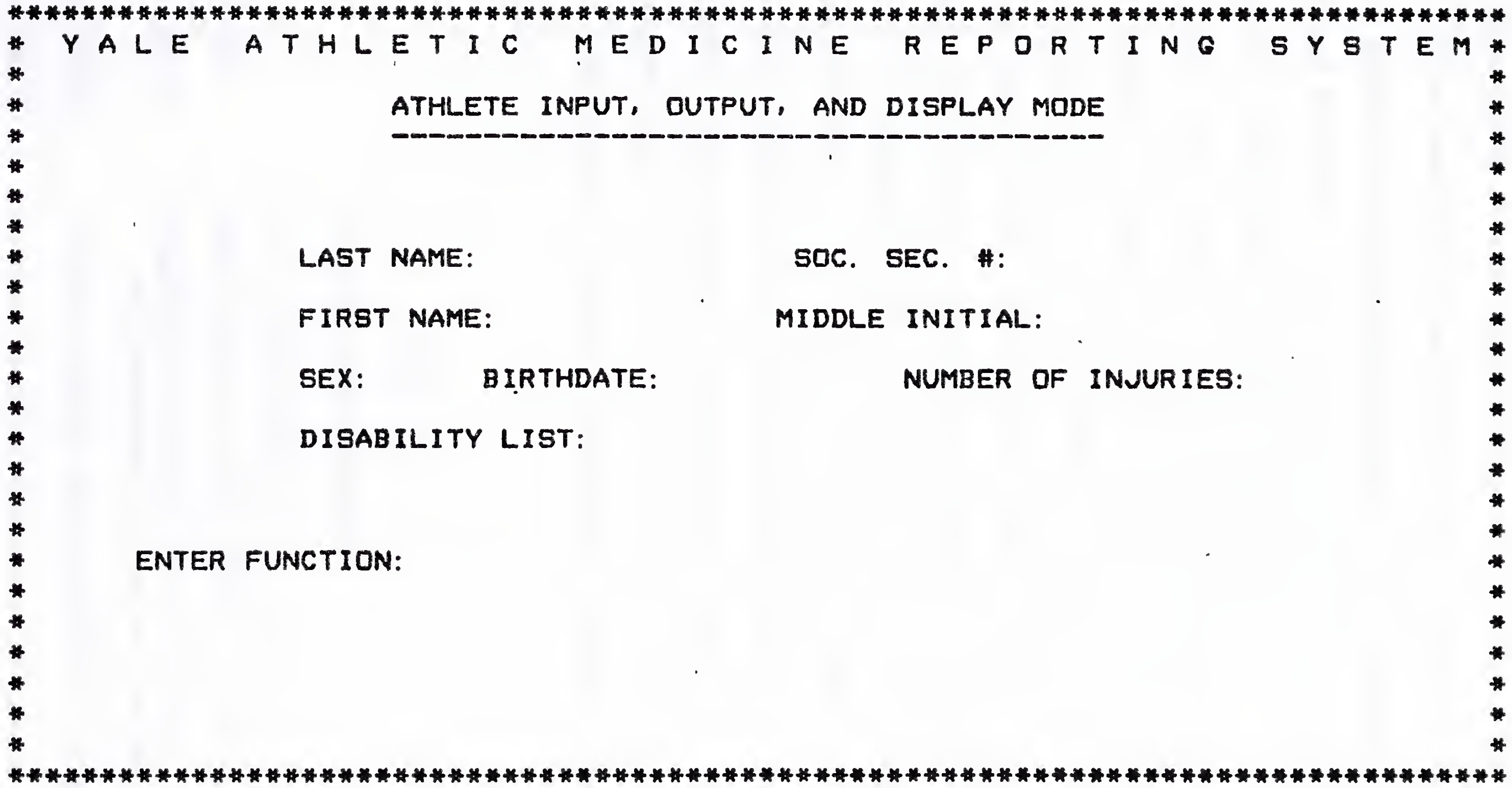
Input and Correction

The input and correction of data is divided into two phases: Athlete data (name, social security number, sex, birthdate) and injury data. The athlete screen (Figure 4) is used to enter new athlete data, correct existing data, and look up athletes by name or social security number. When this mode is initiated, the cursor begins next to "LAST NAME". Four options are available:

(1) New athlete data is entered, in which case an internal check for uniqueness of the new social security number is performed.

(2) Athlete is looked up by entering last name (or portion thereof) and pressing MB II. Time is then allowed for entry of portion of first name, if desired. If the athlete is not found the next alphabetical athlete entry is displayed.

(3) Athlete is looked up by social security number by pressing CR to move the cursor to that category and then entering the number.



```
********************************************************************************
*  Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M*
*                                                                              *
*                   ATHLETE INPUT, OUTPUT, AND DISPLAY MODE                    *
*                   ---------------------------------------                    *
*                                                                              *
*                                                                              *
*                                                                              *
*              LAST NAME:                SOC. SEC. #:                          *
*                                                                              *
*              FIRST NAME:              MIDDLE INITIAL:                        *
*                                                                              *
*              SEX:      BIRTHDATE:            NUMBER OF INJURIES:             *
*                                                                              *
*              DISABILITY LIST:                                                *
*                                                                              *
*                                                                              *
*                                                                              *
*       ENTER FUNCTION:                                                        *
*                                                                              *
*                                                                              *
*                                                                              *
*                                                                              *
*                                                                              *
*                                                                              *
********************************************************************************
```

Figure 4. Screen used to input, correct, and display athletes.

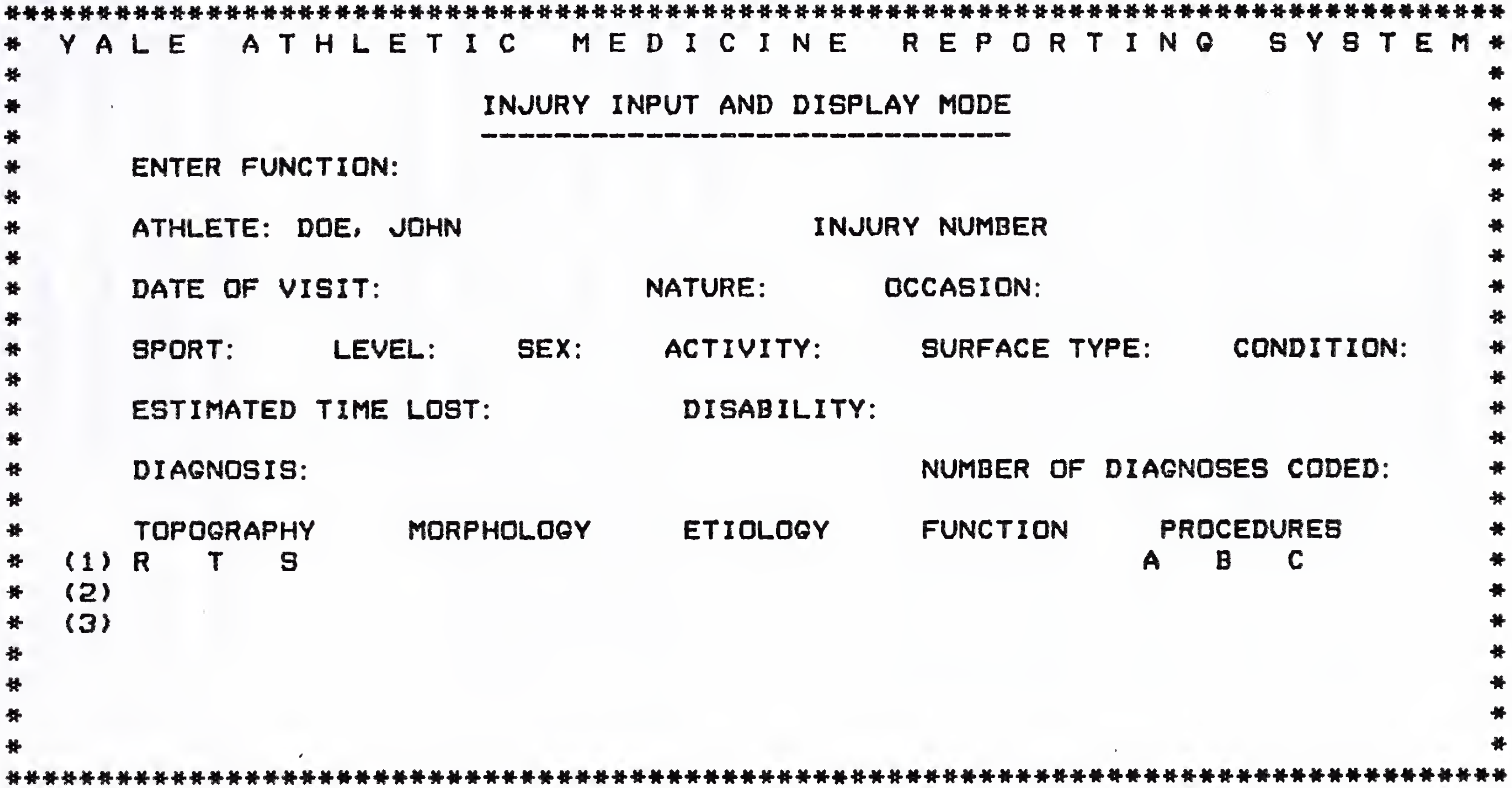
(4) Pressing MB IV will cause the cursor to move to function selection. Upon completion of any of the above options the screen displays an athlete (or explanatory message) and the cursor is located next to "ENTER FUNCTION". Five functions are available (Table 28) including one to allow entry into the injury phase.

The injury screen (Figure 5) is used to enter new injuries as well as to display and correct injuries on file. If the athlete has had no injuries entered, the words "INJURY 1" appear in the upper right of the screen and the cursor begins next to "DATE". The injury data, mostly in the form of codes, is now entered. The computer will not allow any demographic data to be omitted; "X" or "XX" is entered if the data is missing. The "number of diagnoses coded" is requested as the computer can store as many as three separate injury classification components. One component is entered at a time (i.e., one code for each classification axis); the program will not allow data to be omitted, but MB I can be pressed if subsequent components contain the

Table 28

Athlete Mode Functions

Keywords	Function
ATHL or MB I	Moves cursor to "LAST NAME" for additional data entry.
INJY or MB II	Transfers to injury screen for input, correction, and print-out of data for displayed athlete.
NEXT OR MB III	Displays athlete appearing next in alphabetical file.
EXIT or MB IV	Returns to selection screen to choose another mode.
UPDT	Allows correction of data for athlete displayed.



```
********************************************************************************
* Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M*
*                                                                              *
*                        INJURY INPUT AND DISPLAY MODE                         *
*                        -----------------------------                         *
*      ENTER FUNCTION:                                                         *
*                                                                              *
*      ATHLETE: DOE, JOHN                  INJURY NUMBER                       *
*                                                                              *
*      DATE OF VISIT:             NATURE:      OCCASION:                       *
*                                                                              *
*      SPORT:    LEVEL:    SEX:    ACTIVITY:     SURFACE TYPE:   CONDITION:    *
*                                                                              *
*      ESTIMATED TIME LOST:         DISABILITY:                                *
*                                                                              *
*      DIAGNOSIS:                                NUMBER OF DIAGNOSES CODED:    *
*                                                                              *
*      TOPOGRAPHY    MORPHOLOGY     ETIOLOGY     FUNCTION    PROCEDURES        *
*  (1) R   T   S                                             A   B   C         *
*  (2)                                                                         *
*  (3)                                                                         *
*                                                                              *
*                                                                              *
*                                                                              *
*                                                                              *
********************************************************************************
```

Figure 5. Screen used to input, correct, and display injuries.

Table 29

Injury Mode Functions

Keyword	Functions
MB I	Moves cursor to "DATE" to enter new injury.
MB II	Displays 'last' (highest numbered) injury or injury previous to one displayed.
MB III	Displays 'next' injury after one displayed.
MB IV	Returns to athlete mode.
DISP	Displays specified injury (request input of number)
UPDT	Allows correction of data for injury displayed.
PRNT	Prints all injuries for this athlete and returns to athlete mode.

same code in that category.

After completion of entry, and upon initial entry if injuries are already on file, the cursor moves to "ENTER FUNCTION". Seven functions are available, as listed in Table 29. These allow display of sequential or specific injuries, entry and correction of data, and print-out of all injuries for the athlete displayed (Figure 6).

Output

Several different types of output can be obtained. As mentioned above, using the injury mode a complete list of injuries for a single athlete can be printed as shown in Figure 6. Using the "LIST" mode three types of lists can be generated: (1) all athletes, with identification data and number of injuries (Figure 7), (2) those athletes on disability, with team, level, injury date, and diagnosis (Figure 8),

```
                          Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
03/04/81                                                                                                             PAGE  1
                                                  All Injuries of:
                                      SEX: M    SOC. SEC. #: 285-56-4300    BIRTHDATE: 04/15/59

                                               SURFACE    TIME     TOPOGRAPHY
NATURE  OCCASION  SPORT   LV S  ACTIV.   TYPE   COND.  LOST    REGION  TISSUE   S MORPHOLOGY  ETIOLOGY   FUNC.            PROCEDURES

09/09/80 Inj#001                                               DX:  THIGH CONTUSION MYOSITIS OSSIF
new,1st practice footb,tk V  M block-   grass norml 2-4 d   thigh    muscle   R crush/comp t,teammate none  a-inflam act.r,sp exercise
                                                            thigh    bone     R hemorrhage t,teammate none
                                                            thigh    bone     R depos/calc t,teammate none

09/16/80 Inj#002                                               DX:  BILATERAL MEDIAL TIBIAL PAIN
new,1st practice footb,tk V  M running  n/a   n/a   none    leg      fascia   B inflam,nos traum,self none  orthotic
                                                            leg      tendon   B inflam,nos traum,self none

09/23/80 Inj#003                                               DX:  SHINSPLINTS, BILATERAL
new,1st training footb,tk V  M running  grass norml none    leg      fascia   B inflam,acu traum,self none  ad.strap orthotic a-inflam
                                                            leg      tendon   B inflam,acu traum,self none  act.r,sp ice

09/27/80 Inj#004                                               DX:  MULTIPLE CONTUSIONS
new,1st comp.3rd footb,tk V  M tackled  grass norml 2-4 d   body     skin     B hematoma   t,opponent none  ace      a-inflam
                                                            arm      muscle   B inflam,acu t,opponent none
                                                            leg      muscle   B hematoma   t,opponent none

10/25/80 Inj#005                                               DX:  ELBOW SPRAIN; METACARP.CONTUS.
new,1st comp.1st footb,tk V  M tackled  artif wet   5-7 d   elbow    joint    L joint abnl t,opponent none  xray,pos ad.strap antibiot
                                                            hand     bone     R contusion  t,opponent none  ace

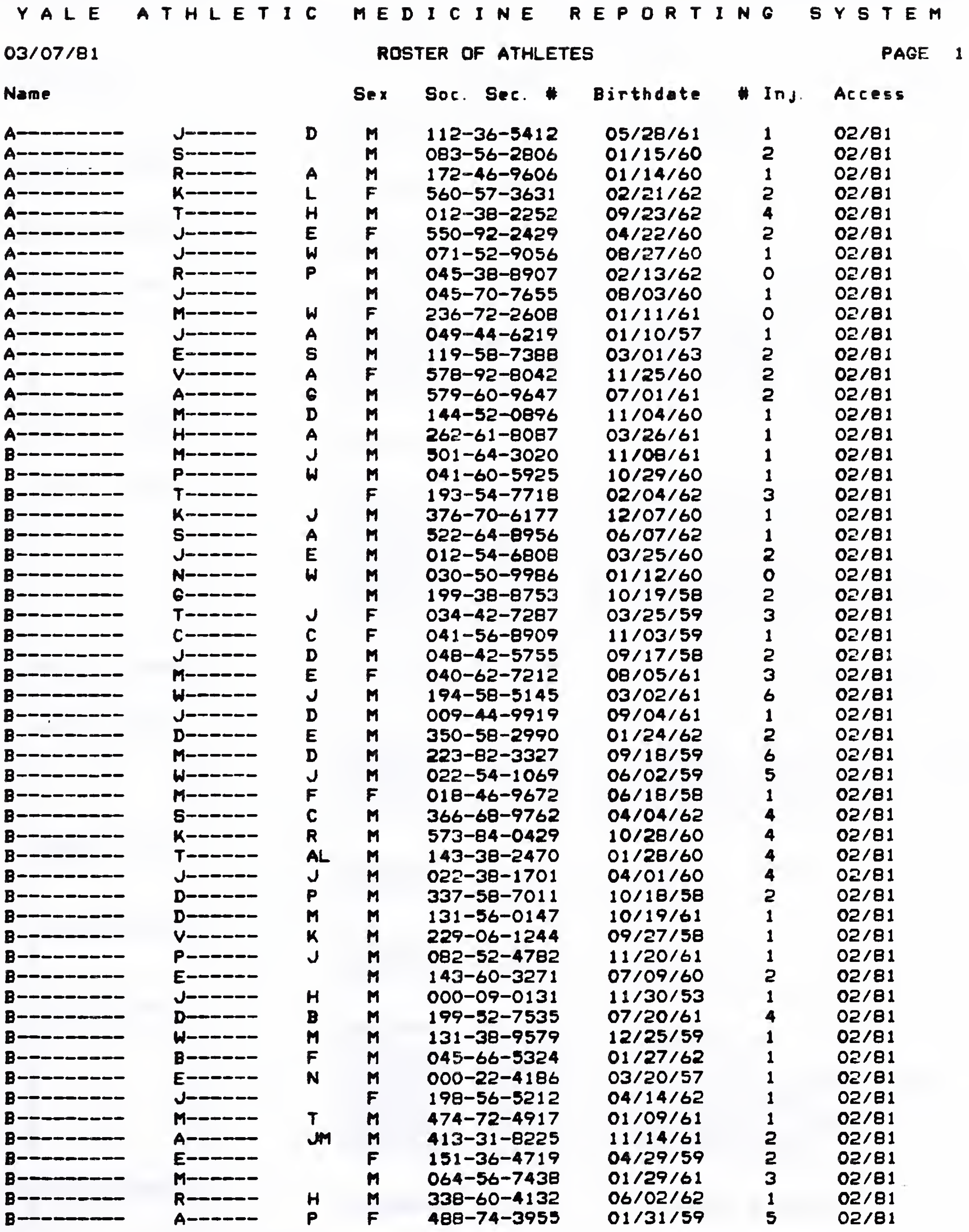
11/20/80 Inj#006                                               DX:  POST. ILIAC CREST CONTUS,SPASM
new,1st practice footb,tk V  M tacklin  grass norml 1 day   pelvis   bone     R contusion  t,sp.equip none  hosp adm drug,nos a-inflam
                                                            l-spine  muscle   R strain     traum,self none  ace      lab,nl   ice
                                                            sacrum   soft,nos R crush/comp traum,self none

11/01/80 Inj#007                                               DX:  CONTUSION ANKLE
 ----    comp.3rd footb,tk V  M tacklin  grass norml none    ankle    bone     L contusion  t,opponent none  ace

11/07/80 Inj#008                                               DX:  BRONCHITIS SINUSITIS
new,1st nonacute footb,tk V  M   n/a    n/a   n/a   2-4 d   body     unspec.  U not abnl   bacterial  resp  antihist antibiot hosp adm
                                                            body     unspec.  U not abnl   viral      resp

11/17/80 Inj#009                                               DX:  ANKLE SPRAIN
recur-s  ------  footb,tk V  M   ---    --    --    1 day   ankle    ligament L sprain     t,opponent none  ad.strap act.rstn part.wt.
```

Figure 6. Print-out of all injuries for a single athlete.



```
 Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M

03/07/81                       ROSTER OF ATHLETES                      PAGE  1

Name                             Sex   Soc. Sec. #   Birthdate   # Inj.   Access

A---------   J------    D         M   112-36-5412   05/28/61      1      02/81
A---------   S------              M   083-56-2806   01/15/60      2      02/81
A---------   R------    A         M   172-46-9606   01/14/60      1      02/81
A---------   K------    L         F   560-57-3631   02/21/62      2      02/81
A---------   T------    H         M   012-38-2252   09/23/62      4      02/81
A---------   J------    E         F   550-92-2429   04/22/60      2      02/81
A---------   J------    W         M   071-52-9056   08/27/60      1      02/81
A---------   R------    P         M   045-38-8907   02/13/62      0      02/81
A---------   J------              M   045-70-7655   08/03/60      1      02/81
A---------   M------    W         F   236-72-2608   01/11/61      0      02/81
A---------   J------    A         M   049-44-6219   01/10/57      1      02/81
A---------   E------    S         M   119-58-7388   03/01/63      2      02/81
A---------   V------    A         F   578-92-8042   11/25/60      2      02/81
A---------   A------    G         M   579-60-9647   07/01/61      2      02/81
A---------   M------    D         M   144-52-0896   11/04/60      1      02/81
A---------   H------    A         M   262-61-8087   03/26/61      1      02/81
B---------   M------    J         M   501-64-3020   11/08/61      1      02/81
B---------   P------    W         M   041-60-5925   10/29/60      1      02/81
B---------   T------              F   193-54-7718   02/04/62      3      02/81
B---------   K------    J         M   376-70-6177   12/07/60      1      02/81
B---------   S------    A         M   522-64-8956   06/07/62      1      02/81
B---------   J------    E         M   012-54-6808   03/25/60      2      02/81
B---------   N------    W         M   030-50-9986   01/12/60      0      02/81
B---------   G------              M   199-38-8753   10/19/58      2      02/81
B---------   T------    J         F   034-42-7287   03/25/59      3      02/81
B---------   C------    C         F   041-56-8909   11/03/59      1      02/81
B---------   J------    D         M   048-42-5755   09/17/58      2      02/81
B---------   M------    E         F   040-62-7212   08/05/61      3      02/81
B---------   W------    J         M   194-58-5145   03/02/61      6      02/81
B---------   J------    D         M   009-44-9919   09/04/61      1      02/81
B---------   D------    E         M   350-58-2990   01/24/62      2      02/81
B---------   M------    D         M   223-82-3327   09/18/59      6      02/81
B---------   W------    J         M   022-54-1069   06/02/59      5      02/81
B---------   M------    F         F   018-46-9672   06/18/58      1      02/81
B---------   S------    C         M   366-68-9762   04/04/62      4      02/81
B---------   K------    R         M   573-84-0429   10/28/60      4      02/81
B---------   T------    AL        M   143-38-2470   01/28/60      4      02/81
B---------   J------    J         M   022-38-1701   04/01/60      4      02/81
B---------   D------    P         M   337-58-7011   10/18/58      2      02/81
B---------   D------    M         M   131-56-0147   10/19/61      1      02/81
B---------   V------    K         M   229-06-1244   09/27/58      1      02/81
B---------   P------    J         M   082-52-4782   11/20/61      1      02/81
B---------   E------              M   143-60-3271   07/09/60      2      02/81
B---------   J------    H         M   000-09-0131   11/30/53      1      02/81
B---------   D------    B         M   199-52-7535   07/20/61      4      02/81
B---------   W------    M         M   131-38-9579   12/25/59      1      02/81
B---------   B------    F         M   045-66-5324   01/27/62      1      02/81
B---------   E------    N         M   000-22-4186   03/20/57      1      02/81
B---------   J------              F   198-56-5212   04/14/62      1      02/81
B---------   M------    T         M   474-72-4917   01/09/61      1      02/81
B---------   A------    JM        M   413-31-8225   11/14/61      2      02/81
B---------   E------              F   151-36-4719   04/29/59      2      02/81
B---------   M------              M   064-56-7438   01/29/61      3      02/81
B---------   R------    H         M   338-60-4132   06/02/62      1      02/81
B---------   A------    P         F   488-74-3955   01/31/59      5      02/81
```

Figure 7. Print-out of athlete roster (partial listing).

```
Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
                          D I S A B I L I T Y   L I S T
11:03 PM                           03/07/81                               PAGE  1

                          SOC. SEC. #  DATE ON   LV  DIAGNOSIS

Archery   MEN
H.           J.           267735115   02/05/81   V   URI

Basketb.  WOMEN
H.           M.           032565425   01/21/81   V   FLU

Basketb.  MEN
C.           B.           023587354   11/17/80   V   TORN ANT. CRUCIATE
V.           J.           047647306   01/15/81   V   LBP, SCIATICA
L.           F.           104541941   02/24/81   V   MUSCLE SPASM
M.           L.           188566128   03/02/81   JV  ANKLE SPRAIN
S.           L.           151502007   01/20/81   IM  KNEE SPRAIN, L MILD

Crew      WOMEN
O.           C.           486641469   02/19/81   V   LBP

Crew      MEN
G.           J.           046661186   02/24/81   V   BICIPITAL TENDINITIS
S.           T.           272642473   02/20/81   V   FX CLAVICLE
P.           K.           561354050   01/23/81   V   INFECTED BLISTER
A.           H.           262618087   03/05/81   JV  LBP
F.           J.           026425183   02/23/81   FR  QUAD CONTUSION, R THIGH
M.           J.           537644619   01/20/81   FR  TENOSYNOVITIS INDEX FING. EXT.
P.           K.           550495698   02/25/81   FR  ? HYPERTENSION

Fencing   WOMEN
V.           H.           131605475   03/02/81   V   ANT. CRUCIATE TEAR, KNEE

Footb,tk  MEN
L.           J.           208563958   01/29/80   V   LIGAMENT INJURY, KNEE
D.           W.           289685668   11/17/80   V   TORN ANT. CRUCIATE LIG., KNEE
B.           W.           194585145   11/17/80   JV  KNEE CAPSULE TEAR
C.           S.           395607818   12/15/80   FR  FX DISLOCATION, ANKLE

Gymnast.  WOMEN
P.           R.           000224107   01/19/81   V   SPRAIN L ANKLE
S.           L.           216665191   01/22/81   V   FLU

Ice hock  WOMEN
W.           A.           025365116   02/02/81   V   FLU
E.           L.           469607587   01/28/81   V   SORETHROAT

Ice hock  MEN
T.           D.           000224783   02/09/81   V   FX ULNA
C.           P.           013384669   12/13/80   V   CONCUSSION
M.           G.           120502015   01/28/81   V   FLU,  URI
W.           B.           625707385   01/20/81   V   BRONCHITIS, DORSAL SPASM
M.           E.           000224383   02/13/81   JV  A-C SEPARATION
G.           D.           372667730   11/20/80   JV  CONTUSION L THIGH
B.           C.           450574132   02/24/81   IM  SPRAINED ANKLE

Lacrosse  WOMEN
K.           A.           046685894   02/12/81   V   SPRAINED R ANKLE
```

Figure 8. Print-out of athletes on disability (partial listing).

and (3) a tabulation of number of entries in any single axis (Figure 9).

In order to retrieve specific injury data, a program employing the output screen (Figure 10) is used. One can select restriction on range of dates and disability time, suppression of athlete names, order of print-out, and exclusion of follow-up visits. One then chooses the primary search parameter (i.e., search in main cross reference file DSWCXB) by entering the letter (for classification codes) or number (for demographic codes) prefix associated with the desired category. The appropriate code or code range is then entered. Additional codes, up to one in each category, can be entered to select only certain injuries of those found in the primary search. After confirmation that the parameters are correct, the search begins.

When complete, the screen will display the total number of injuries found and a breakdown into number of new injuries, recurrances, and follow-up visits. These injuries found can then be printed, if desired. The standard format of this output is exemplified by the print-out shown in Figure 11. The beginning of each print-out contains a description of the search parameters. Following this are the injuries themselves. For each, the left half of the page consists of demographic data: the first line contains the date of visit, sex of athlete and injury number (e.g., "M002"), social security number, and full name (if requested); the second line contains the translation (often abbreviated) of the demographic codes. The right half of the page consists of the injury description: the first line lists the written diagnosis and the disability list information, if applicable; subsequent lines contain abbreviated translations of the injury classification (SNOMED) codes. The appearance of dashes instead of any translation implies that no code was supplied.

```
              Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
03/07/81
```

Sport

```
TOTAL OF 1254 INJURIES TABULATED:
archery        2   baseball      11   basketb.      69   crew         116   css-coun      32   curling        1
fencing       17   fld.hock      16   footb,tk     316   footb,ot      19   golf           1   gymnast.      18
ice hock     103   judo           1   lacrosse      67   rodeo          1   rugby          2   soccer       191
softball       2   squash        30   swim/div      33   tennis        26   trk&fld      108   volleyb.      11
wat.polo       1   wt.lift        7   wrestlin      36   other         15
```

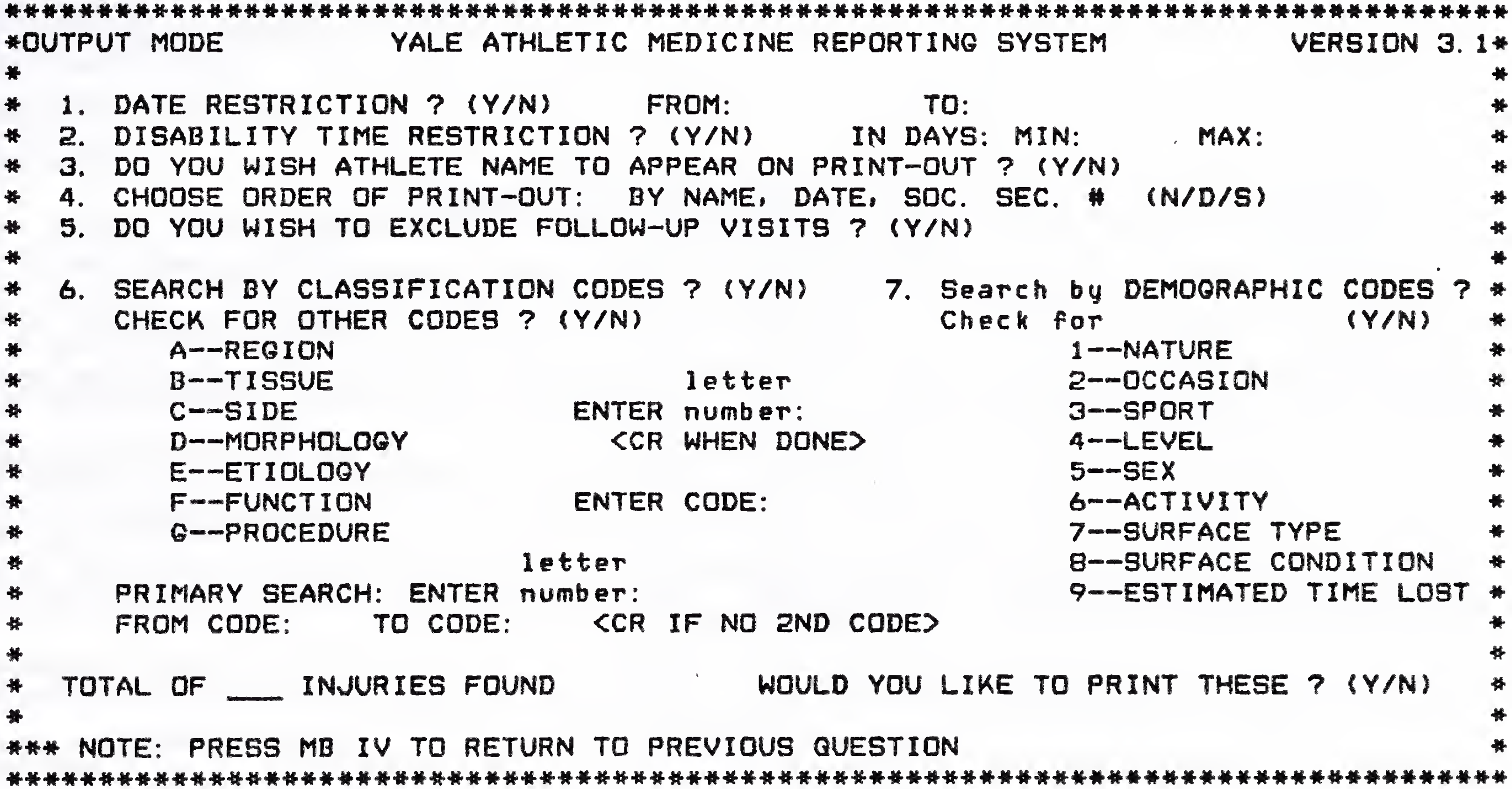
Occasion

```
TOTAL OF 1240 INJURIES TABULATED:
nonacute     189   sprt,nos     148   practice     313   scrimmag      58   comp,nos     106   comp.1st      47
comp.2nd      58   comp.3rd      65   comp.4th      21   locker         7   travel         1   training      58
not sprt     166
```

Surf. Type

```
TOTAL OF 729 INJURIES TABULATED:
 n/a           1   artif         34   aspht         25   clay           5   concr         27   dirt          54
grass        389   mat           38   wood          71   other         85
```

Figure 9. Tabulation of injuries in a single category.



```
**********************************************************************************
*OUTPUT MODE         YALE ATHLETIC MEDICINE REPORTING SYSTEM          VERSION 3.1*
*                                                                                *
*  1. DATE RESTRICTION ? (Y/N)     FROM:          TO:                            *
*  2. DISABILITY TIME RESTRICTION ? (Y/N)     IN DAYS: MIN:      MAX:            *
*  3. DO YOU WISH ATHLETE NAME TO APPEAR ON PRINT-OUT ? (Y/N)                    *
*  4. CHOOSE ORDER OF PRINT-OUT:  BY NAME, DATE, SOC. SEC. #  (N/D/S)            *
*  5. DO YOU WISH TO EXCLUDE FOLLOW-UP VISITS ? (Y/N)                            *
*                                                                                *
*  6. SEARCH BY CLASSIFICATION CODES ? (Y/N)    7. Search by DEMOGRAPHIC CODES ? *
*     CHECK FOR OTHER CODES ? (Y/N)                Check for             (Y/N)   *
*        A--REGION                                        1--NATURE              *
*        B--TISSUE                   letter               2--OCCASION            *
*        C--SIDE               ENTER number:              3--SPORT               *
*        D--MORPHOLOGY           <CR WHEN DONE>           4--LEVEL               *
*        E--ETIOLOGY                                      5--SEX                 *
*        F--FUNCTION           ENTER CODE:                6--ACTIVITY            *
*        G--PROCEDURE                                     7--SURFACE TYPE        *
*                           letter                        8--SURFACE CONDITION   *
*     PRIMARY SEARCH: ENTER number:                       9--ESTIMATED TIME LOST *
*     FROM CODE:    TO CODE:    <CR IF NO 2ND CODE>                              *
*                                                                                *
*  TOTAL OF ___ INJURIES FOUND           WOULD YOU LIKE TO PRINT THESE ? (Y/N)   *
*                                                                                *
*** NOTE: PRESS MB IV TO RETURN TO PREVIOUS QUESTION                             *
**********************************************************************************
```

Figure 10. Screen used to retrieve injuries.

```
                Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
03/01/81                                                                                                   PAGE  1

TOTAL OF 10 INJURIES        New,1st visit  6    Recur-season  2    Recur <1 yr  1    Recur >1 yr  1    Follow-up  0

SEARCH PARAMETERS:
Date Restriction:  From 08/01/80 to 02/28/81
Disability Time Restriction:  None
Follow-up Visits Excluded

Primary Search:   Region--ankle

Other Restrictions:
Sport--basketb.

                                            SURFACE   TIME       TOPOGRAPHY
NATURE  OCCASION   SPORT   LV S  ACTIV.  TYPE  COND.  LOST   REGION   TISSUE  S MORPHOLOGY  ETIOLOGY  FUNC.        PROCEDURES

09/11/80  002-56-8968  Injury# 001                           DX: INVERSION SPRAIN, ANKLE
new,1st training basketb. V  F jumping wood  norml 2-4wk   ankle     ligament L sprain      t,opponent none  xray,neg cast,on

10/09/80  012-38-2252  Injury# 002                           DX: ANKLE SPRAIN
new,1st sprt,nos basketb. IN M lifting wood  norml 2-4 d   ankle     ligament R sprain      traum,self none  ace      ad.strap

12/02/80  104-54-1941  Injury# 002                           DX: ANKLE SPRAIN                                     Disability List:  58 days
new,1st practice basketb. V  M jumping wood  norml 1-2wk   ankle     ligament R sprain      t,opponent none  ace      cast,on  non-wt
                                                           ankle     ligament R j-effusion  t,opponent none  ad.strap

02/02/81  188-56-6128  Injury# 002                           DX: POST TIBIAL STRAIN
recur<1 comp,nos basketb. JV M running wood  norml  ---    ankle     tendon   R strain      t,opponent none  orthotic

01/12/81  188-56-6128  Injury# 001                           DX: HYPERMOBILE ANKLE
recur-s practice basketb. JV M  n/a    n/a    n/a   ---    ankle     joint    L j,hypermob iatrogenic none  ad.strap

01/27/81  286-72-2509  Injury# 005                           DX: ANKLE SPRAIN                                     Disability List:  28 days
new,1st training basketb. 1M M jumping wood  norml >1 mn   ankle     ligament R sprain      traum,self none  non-wt   other     cast,on
                                                           ankle     ligament R sprain      traum,self none  xray,neg rest,cpt exercise
                                                           ankle     ligament R sprain      traum,self none  cast,adj part.wt. cast,off

10/27/80  441-70-5809  Injury# 002                           DX: SPRAIN L ANKLE, MILD
recur-s practice basketb. V  M jumping wood  norml 1 day   ankle     ligament L sprain      t,opponent none  ad.strap act.r,sp part.wt
                                                           ankle     ligament L joint abnl  t,opponent none

11/10/80  522-86-0980  Injury# 001                           DX: CONTUSION, L MEDIAL ANKLE
new,1st practice basketb. V  F tackled wood  norml none    ankle     soft,nos L contusion   t,teammate none  orthotic

01/14/81  545-21-7488  Injury# 001                           DX: ANKLE SPRAINS, CHRONIC
recur>1 sprt,nos basketb. 1M M  ---    n/a    n/a   ---    ankle     ligament B sprain      traum,self none  ad.strap
                                                           ankle     ligament B sprain      t,teammate none

02/17/81  550-70-4679  Injury# 001                           DX: ANKLE SPRAIN, L
new,1st practice basketb. 1M F dribbl- artif norml  ---    ankle     ligament L sprain      t,teammate none  ad strap exercise
```

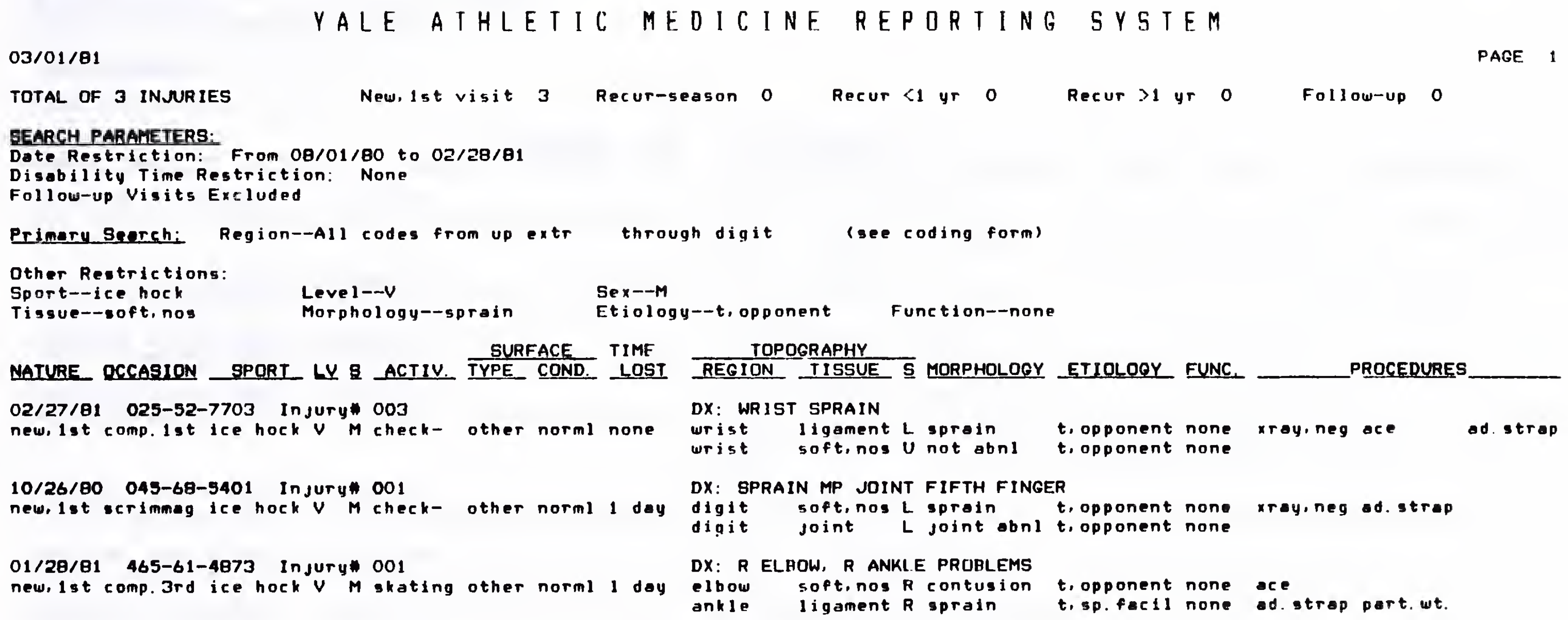
Figure 11. Sample of injury retrieval output: ankle injuries to basketball players.

DISCUSSION

The Yale Athletic Medicine Reporting System provides a reliable method for the storage and retrieval of athletic injury data. Retrospective studies using stored data augmented by review of medical records are easily carried out. Information about the circumstances surrounding the injury is also stored by the computer; such data is usually not present in medical records. Search for injuries may be as specific (Figure 12) or general (Figure 13) as desired.

Interest might be expressed in performing a study of injuries occurring in a single region in one sport. This may be in response to an anecdotal report, such as "we see many ankle injuries to basketball players." The results of such a search (Figure 11) shows ten injuries, mostly ankle sprains. With a larger number of injuries it might be necessary to subdivide the injuries, for example by etiology (self, teammate, or opponent), occasion (practice or competition), or activity. This could be easily accomplished by adding a parameter to the search. Similarly, an interest in back injuries in crew would suggest a search by all back regions (unspecified through coccyx, Table 11) with sport coded as crew (Figure 14). For either of these searches, comparisons between levels and sexes could be made to examine differences in injury type and severity.

An inquiry might be received about a sudden rash of concussions on the soccer team. Retrieval of head injuries in soccer players (Figure 15) and comparisons to previous years results would help determine whether there had been a disproportionate number of concussions. Examination for the presence of wet surface conditions would be important since



```
                         Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
03/01/81                                                                                                      PAGE  1

TOTAL OF 3 INJURIES          New,1st visit  3    Recur-season  0     Recur <1 yr  0     Recur >1 yr  0     Follow-up  0

SEARCH PARAMETERS:
Date Restriction:   From 08/01/80 to 02/28/81
Disability Time Restriction:   None
Follow-up Visits Excluded

Primary Search:   Region--All codes from up extr    through digit      (see coding form)

Other Restrictions:
Sport--ice hock          Level--V                 Sex--M
Tissue--soft,nos         Morphology--sprain       Etiology--t,opponent      Function--none

                                                  SURFACE    TIME       TOPOGRAPHY
NATURE  OCCASION   SPORT   LV S  ACTIV.  TYPE  COND.  LOST    REGION    TISSUE   S MORPHOLOGY  ETIOLOGY   FUNC.          PROCEDURES

02/27/81   025-52-7703   Injury# 003                          DX:  WRIST SPRAIN
new,1st comp.1st ice hock  V   M check-  other norml none     wrist     ligament L sprain      t,opponent none  xray,neg ace        ad.strap
                                                              wrist     soft,nos U not abnl    t,opponent none

10/26/80   045-68-5401   Injury# 001                          DX:  SPRAIN MP JOINT FIFTH FINGER
new,1st scrimmag ice hock  V   M check-  other norml 1 day    digit     soft,nos L sprain      t,opponent none  xray,neg ad.strap
                                                              digit     joint    L joint abnl  t,opponent none

01/28/81   465-61-4873   Injury# 001                          DX:  R ELBOW, R ANKLE PROBLEMS
new,1st comp.3rd ice hock  V   M skating other norml 1 day    elbow     soft,nos R contusion   t,opponent none  ace
                                                              ankle     ligament R sprain      t,sp.facil none  ad.strap part.wt.
```

Figure 12. Example of a very specific injury search.

```
                          YALE ATHLETIC MEDICINE REPORTING SYSTEM
03/04/81                                                                                          PAGE  1

TOTAL OF 309 INJURIES     New,1st visit  184  Recur-season  28   Recur <1 yr  6    Recur >1 yr  7    Follow-up  73

SEARCH PARAMETERS:
Date Restriction:  From 08/01/80 to 02/28/81
Disability Time Restriction:  None

Primary Search:   Sport--footb,tk

Other Restrictions:   None

                                        SURFACE    TIME    TOPOGRAPHY
NATURE   OCCASION  SPORT    LV S ACTIV.  TYPE  COND.  LOST    REGION   TISSUE   S MORPHOLOGY ETIOLOGY   FUNC.        PROCEDURES

10/25/80  000-22-6216  Injury# 001                           DX: R WRIST, TENDINITIS
new,1st practice footb,tk IM M lifting grass norml 5-7 d     wrist    tendon   R strain     traum,self none  cast,on  aspirin  act.rstn
                                                             wrist    tendon   R strain     traum,self none  ice

09/23/80  003-38-9735  Injury# 001                           DX: L TRAPEZIUS STRAIN
new,1st scrimmag footb,tk IM M tackled grass norml none      neck,nos muscle   L strain     t,opponent none  cast,on  met.heat

10/25/80  009-44-9082  Injury# 002                           DX: CONTUSION, DELTOID
 ----    comp.1st footb,tk V  M tacklin artif wet   none     shoulder muscle   R contusion  t,opponent none  ace      cast,on

10/20/80  009-44-9082  Injury# 001                           DX: FACET SUBLUXATION, NECK
new,1st practice footb,tk V  M catch-  grass norml none      c-spine  joint    R crush/comp traum,self none  traction act.r,sp hydrocol
                                                             c-spine  synovium R subluxed   traum,self none
                                                             c-spine  nerve    R subluxed   traum,self none

09/31/80  009-44-9919  Injury# 001                           DX: SPRAIN, WRIST
new,1st scrimmag footb,tk V  M tackled grass norml none      wrist    ligament R sprain     traum,self none  xray,neg ad.strap cast,on

10/00/80  013-52-6319  Injury# 002                           DX: MCL L KNEE SPRAIN
fol/up   comp,nos footb,tk IM M tackled grass norml 1-2wk    knee     ligament L sprain     t,sp.facil none  exercise

10/08/80  013-52-6319  Injury# 001                           DX: L KNEE SPRAIN, LATERAL LIG
new,1st comp,nos footb,tk IM M tacklin grass norml none      knee     ligament L sprain     traum,self none  ace      non-wt.

01/14/81  014-56-6325  Injury# 003                           DX: DEGENERATIVE ARTHRITIS, THUMB
recur>1 sprt,nos footb,tk V  F block-   n/a    n/a  none     digit    bone     L degen,nos  trauma,nos none  ref-yhp
                                                             digit    joint    L joint abnl trauma,nos none
                                                             digit    cartilag L joint abnl trauma,nos none

11/13/80  014-56-6325  Injury# 002                           DX: R THUMB SPRAIN, L MCP DEGENERA
recur>1 practice footb,tk V  M block-  grass norml none      digit    ligament R sprain     traum,self none  xray,pos cast,on  ad.strap
                                                             digit    ligament L bone spur  traum,self none
                                                             digit    ligament L degen,nos  traum,self none

10/09/80  014-56-6325  Injury# 001                           DX: U.R.I.
new,1st nonacute footb,tk V  M   n/a    n/a    n/a  none     body     unspec.  U inflam,acu viral      resp'  lab test antihist

01/21/81  022-54-1069  Injury# 004                           DX: URI
new,1st not sprt footb,tk V  M   n/a    n/a    n/a  none       ----   unspec.  U not abnl   viral      resp  antihist

11/14/80  022-54-1069  Injury# 003                           DX: SPRAIN, RING FINGER
recur-s practice footb,tk V  M block-  grass norml none      digit    ligament L j-effusion t,teammate none  xray,neg ad.strap
                                                             digit    ligament L sprain     t,teammate none
```

Figure 13. Example of a general injury search (partial listing).

```
                         Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
03/01/81                                                                                                                PAGE  1

TOTAL OF 14 INJURIES          New,1st visit  10   Recur-season  0     Recur <1 yr  3     Recur >1 yr  1      Follow-up  0

SEARCH PARAMETERS:
Date Restriction:   From 08/01/80 to 02/28/81
Disability Time Restriction:  None
Follow-up Visits Excluded

Primary Search:   Region--All codes from back,nos   through coccyx     (see coding form)

Other Restrictions:
Sport--crew
                                                   SURFACE    TIME          TOPOGRAPHY
NATURE  OCCASION   SPORT  LV S  ACTIV.  TYPE  COND.  LOST   REGION   TISSUE   S MORPHOLOGY ETIOLOGY   FUNC.        PROCEDURES

09/12/80  074-40-4762  Injury# 001                          DX: LUMBOSACRAL STRAIN
recur<1 training crew    V  F other    n/a   n/a  none    l-spine  muscle   U strain                none  exercise
                                                            sacrum   ligament U lordosis              none

02/10/81  094-58-4173  Injury# 001                          DX: LBP                                         Disability List:    8 days
recur>1 sprt,nos crew    V  F   ---    n/a   n/a  2-4 d   t-spine  muscle   B strain     traum,self none  hydrocol aspirin  act.r,sp
                                                            l-spine  muscle   B strain     t,sp.equip none  ref-yhp

10/30/80  111-38-8187  Injury# 001                          DX: LBP
new,1st practice crew    FR F rowing   n/a   n/a  5-7 d   t-spine  muscle   B strain     traum,self none  exercise mst.heat ref-yhp
                                                            l-spine  muscle   B strain     traum,self none

01/19/81  113-58-9264  Injury# 005                          DX: L THORACIC PAIN
new,1st training crew    V  M lunging  n/a   n/a  none    t-spine  muscle   L strain     traum,self none  act.r,sp mst.heat

01/23/81  200-36-6530  Injury# 001                          DX: LBP
new,1st nonacute crew    FR M rowing   other n/a  none    l-spine  soft,nos B inflam,nos traum,self none  act.r,sp

01/26/81  228-68-4662  Injury# 001                          DX: LBP, PARASPINAL MUSC SPASM                  Disability List:    3 days
new,1st not sprt crew    V  M   n/a    wood  n/a  1 day   t-spine  muscle   L contusion  traum,self none  lab test act.r,sp hydrocol
                                                            l-spine  muscle   L contusion  traum,home none

02/03/81  237-19-4781  Injury# 001                          DX: LBP                                         Disability List:    8 days
new,1st practice crew    V  M rowing   --    --   5-7 d   l-spine  muscle   B strain     traum,self none  hydrocol aspirin  referral
                                                            l-spine  ligament B sprain     t,sp equip none
                                                            l-spine  ligament B inflam,acu t,sp equip none

10/27/80  352-54-2844  Injury# 001                          DX: PARASPINAL SPASM
new,1st practice crew    FR F lifting  n/a   n/a  1 day   t-spine  muscle   B strain     traum,self none  exercise mst.heat
                                                            l-spine  muscle   B strain     traum,self none

02/09/81  410-02-8845  Injury# 003                          DX: LBP                                         Disability List:    7 days
recur<1 practice crew    V  M lifting  n/a   n/a  ---     l-spine  muscle   B inflam,acu iatrogenic none  aspirate act.rstn
                                                            l-spine  muscle   B inflam,acu t,sp.facil none
                                                            l-spine  muscle   B inflam,acu t,sp.equip none

02/02/81  410-02-8845  Injury# 001                          DX: LBP
new,1st  ------  crew    V  - lifting  n/a   n/a  ---     l-spine  soft,nos B strain     traum,self none  exercise hydrocol
                                                            sacrum   soft,nos B strain     traum,self none
```

Figure 14. Back injuries to the crew teams (partial listing).

```
                           Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
03/01/81                                                                                                                        PAGE  1

TOTAL OF 7 INJURIES            New,1st visit  7    Recur-season  0      Recur <1 yr  0      Recur >1 yr  0      Follow-up  0

SEARCH PARAMETERS:
Date Restriction:  From 08/01/80 to 02/28/81
Disability Time Restriction:  None

Primary Search:   Region--head,nos

Other Restrictions:
Sport--soccer

                                          SURFACE   TIME        TOPOGRAPHY
NATURE  OCCASION   SPORT   LV S  ACTIV. TYPE  COND. LOST    REGION   TISSUE  S MORPHOLOGY   ETIOLOGY  FUNC.         PROCEDURES

10/06/80  056-46-6921   Injury# 001                        DX:  ? CONCUSSION,  MILD
new,1st sprt,nos soccer    IM M lunging grass norml none   head,nos unspec.  U contusion  t,sp.facil nerv   rest,cpt

09/11/80  078-58-9682   Injury# 001                        DX:  SPRAIN TM JOINT
new,1st practice soccer    V  F other   grass norml none   head,nos joint    L sprain     t,sp equip none
                                                           head,nos ligament L sprain     t,sp equip none

09/19/80  081-42-3630   Injury# 001                        DX:  CONCUSSION
new,1st comp.4th soccer    IM M tacklin grass norml 5-7 d  head,nos unspec.  U not abnl   traum,self nerv   cast,on
                                                           neck,nos nerve    U not abnl   t,opponent nerv
                                                           neck,nos muscle   U not abnl   t,opponent nerv

09/13/80  143-60-3271   Injury# 001                        DX:  CONCUSSION
new,1st comp.3rd soccer    V  M kicking grass norml 1 day  head,nos nerve    R crush/comp t,opponent nerv

10/20/80  155-56-6351   Injury# 002                        DX:  LACERATION,  SCALP
new,1st practice soccer    V  M heading grass norml 1 day  head,nos skin     R laceration t,teammate none   antibiot suturing

10/18/80  157-54-9090   Injury# 002                        DX:  CONCUSSION                                  Disability List:    7 days
new,1st comp.4th soccer    V  M heading grass wet   1-2wk  head,nos viscera  U crush/comp trauma,nos nerv

10/13/80  215-52-6545   Injury# 001                        DX:  CONCUSSION                                  Disability List:    7 days
new,1st scrimmag soccer    JV M heading grass norml 1-2wk  head,nos bone     U not abnl   t,teammate nerv   hosp adm
```

Figure 15. Head injuries to soccer players.

heading a heavy, water-laden soccer ball is known to be a cause of concussions. Other factors such as activity (lunging, diving, kicked) and etiology could also be checked. If no explanation for a significant increase in injuries could be found, further investigation might focus on any changes that had taken place in the practice regimen, coaching techniques, protective equipment, or official rules.

Athletes suffer some injuries outside of sports activities. It is possible to investigate their occurrence by searching for traumatic etiologies coded as home/dorm, work/school, bicycle, or motor vehicle. A total of ten injuries are found, as shown in Figure 16. Review of medical records for these injuries might be helpful to gain additional information on exact cause.

Concern about artificial surfaces is often expressed both by coaches and athletes. Retrieval of injuries with this surface type is shown in Figure 17. Further breakdown could be made for normal and abnormal surface conditions. The calculation of injury rates for comparison would require knowledge of the number of times athletes were exposed to each type field. For example, in a study of soccer injuries using this system (vide infra) there is a significantly higher rate of injuries on artificial turf versus grass.

If information on a particular injury, such as meniscal tears, is desired, a specific search can be made. In this case parameters would include region coded as knee, tissue coded as cartilage, and morphology coded as tear. Eight injuries are found, as shown in Figure 18. Information on whether arthroscopy or surgery was required help to describe the severity of the injury.

```
                    Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
03/01/81                                                                                                              PAGE  1

TOTAL OF 10 INJURIES          New, 1st visit  6    Recur-season  0     Recur <1 yr  1      Recur >1 yr  1      Follow-up  2

SEARCH PARAMETERS:
Date Restriction:  From 08/01/80 to 02/28/81
Disability Time Restriction:  None

Primary Search:  Etiology--All codes from traum, home through t, vehicle  (see coding form)

Other Restrictions:  None

                                              SURFACE    TIME        TOPOGRAPHY
NATURE  OCCASION   SPORT  LV S  ACTIV.   TYPE  COND.   LOST    REGION   TISSUE   S MORPHOLOGY  ETIOLOGY   FUNC.          PROCEDURES

02/23/81  033-52-7401  Injury# 004                            DX:  TEAR, BICEPS TENDON, R
new, 1st not sprt footb, tk V  M wrestle  n/a    n/a   5-7 d  shoulder muscle    R tear        t, opponent none  cast, on
                                                              arm      tendon    R hematoma    traum, home none
                                                              arm      tendon    R hemorrhage  traum, home none

01/15/81  049-56-0962  Injury# 001                            DX:  FX SPINOUS PROCESS C7
recur<1 not sprt swim/div V  F other    concr norml >1 mn     c-spine  fascia    B flexion     t, vehicle  none  xray, pos cast, on   exercise
                                                              c-spine  ligament  B fract, clsd t, vehicle  none
                                                              c-spine  bone      B j, hypermob t, vehicle  none

01/12/81  224-04-7153  Injury# 001                            DX:  SUBLUXATION, PATELLA
fol/up  nonacute soccer   IN -    n/a    n/a    n/a   none    knee     joint     L joint abnl  t, vehicle  none
                                                              knee     cartilag  L subluxed    t, vehicle  none

01/26/81  228-68-4662  Injury# 001                            DX:  LBP, PARASPINAL MUSC SPASM                   Disability List:   3 days
new, 1st not sprt crew     V  M    n/a    wood   n/a   1 day  t-spine  muscle    L contusion   traum, self none  lab test act. r, sp hydrocol
                                                              l-spine  muscle    L contusion   traum, home none

01/26/81  283-58-3157  Injury# 001                            DX:  LACERATIONS
new, 1st not sprt footb, tk V  M    n/a    artif norml none   digit    skin      R laceration  traum, self none  ster. drs
                                                              hand     skin      R laceration  traum, home none

01/28/81  292-66-3868  Injury# 001                            DX:  CONTUSION, R FOOT
new, 1st not sprt crew     FR M    n/a    n/a    n/a   5-7 d  foot     fascia    R contusion   traum, home none  ace      non-wt.   ref-yhp
                                                              foot     soft, nos R hematoma    traum, home none

02/16/81  375-72-9793  Injury# 004                            DX:  FX GRT TOE
fol/up  not sprt footb, tk V  M    n/a    n/a    n/a   1-2wk  toe      bone      R fract, nos  traum, work none  ster. drs

09/13/80  376-70-6177  Injury# 001                            DX:  BURN RIGHT SHOULDER
new, 1st not sprt    --    - -    n/a    n/a    n/a   none    shoulder skin      R heat        traum, home none  ster. drs antibiot

02/19/81  573-25-1270  Injury# 002                            DX:  BLISTER ON FOOT, ALLERGEY TAPE
recur>1 practice trk&fld  V  F running dirt   --     none     foot     skin      R fric. blist t, sp. equip none  padding   ster. drs
                                                              foot     skin      R fric. blist traum, home none

12/08/80  578-92-8042  Injury# 001                            DX:  ULNAR NERVE CONTUSION
new, 1st not sprt fencing  JV F    n/a    n/a    n/a   none   elbow    nerve     L contusion   traum, self none  orthotic
                                                              elbow    nerve     L contusion   traum, home none
```

Figure 16. Injuries with traumatic etiologies outside of sports.

```
                    Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
03/04/81                                                                                                        PAGE  1

TOTAL OF 32 INJURIES          New,1st visit  19   Recur-season  4     Recur <1 yr   0      Recur >1 yr   0      Follow-up  6

SEARCH PARAMETERS:
Date Restriction:   From 08/01/80 to 02/28/81
Disability Time Restriction:   None

Primary Search:    Surf. Type--artif

Other Restrictions:    None

                                           SURFACE    TIME        TOPOGRAPHY
NATURE  OCCASION   SPORT  LV S  ACTIV.  TYPE  COND.  LOST    REGION   TISSUE  S MORPHOLOGY  ETIOLOGY  FUNC.        PROCEDURES

10/25/80  009-44-9082  Injury# 002                          DX:  CONTUSION, DELTOID
 ----    comp.1st footb,tk V  M tacklin artif wet    none   shoulder muscle    R contusion  t,opponent none  ace      cast,on

10/25/80  022-42-7915  Injury# 004                          DX:  CONTUSION L KNEE
recur-s comp,nos soccer   V  M other   artif wet    none   knee      soft,nos L contusion  traum,self none  ace

10/20/80  022-42-7915  Injury# 003                          DX:  CONTUSION, L KNEE                          Disability List:   2 days
fol/up   comp,nos soccer   V  M kicked  artif norml 1 day   knee      muscle   L contusion  t,opponent none  ace
                                                            knee      fascia   L hematoma   t,opponent none

10/10/80  022-42-7915  Injury# 001                          DX:  TRAUMATIC SYNOVITIS
new,1st comp.3rd soccer   V  M sliding artif norml 2-4 d    knee      joint    L crush/comp t,opponent none  ace      cast,on
                                                            knee      synovium L j-effusion t,opponent none

10/22/80  038-38-2543  Injury# 002                          DX:  THIGH CONTUSION
fol/up   comp.3rd soccer  JV M   n/a    artif norml 2-4 d   thigh     muscle   L contusion  t,opponent none  cast,on  exercise
                                                            thigh     muscle   L hematoma   t,opponent none

10/22/80  038-38-2543  Injury# 001                          DX:  THIGH CONTUSION                            Disability List:   8 days
new,1st comp.3rd soccer  JV M tackled artif norml none      thigh     muscle   L contusion  t,opponent none  ace      act.rstn part.wt.
                                                            thigh     muscle   L hemorrhage t,opponent none

02/24/81  041-62-7289  Injury# 003                          DX:  QUAD STRAIN
new,1st not sprt trk&fld  V  M running artif norml  ---     knee      muscle   R strain     traum,self none
                                                            knee      tendon   R strain     traum,self none

10/25/80  041-64-4360  Injury# 002                          DX:  MCL SPRAIN KNEE
new,1st comp.4th footb,tk V  M tackled artif wet    none    knee      joint    L sprain     t,opponent none
                                                            knee      ligament L sprain     t,opponent none

10/25/80  047-64-9124  Injury# 002                          DX:  SPRAIN ANTERIOR CRUCIATE, MCL
fol/up   comp.3rd footb,tk V  M tackled artif wet    2-4wk  knee      tendon   L j,hypermob t,opponent none
                                                            knee      ligament L sprain     t,opponent none
                                                            knee      ligament L tear       t,opponent none

10/11/80  047-64-9124  Injury# 001                          DX:  MCL SPRAIN, KNEE
new,1st comp.3rd footb,tk V  M tackled artif wet    1-2wk   knee      joint    L strain     t,opponent none  x-ray    ace      cast,on
                                                            knee      ligament L tear       t,opponent none  hosp adm

10/22/80  048-42-1117  Injury# 002                          DX:  ANKLE CONTUSION, SPRAIN                    Disability List:   1 days
new,1st comp.3rd soccer   V  M running artif norml 1 day    ankle     joint    R contusion  traum,self none  ad.strap part.wt.
                                                            ankle     ligament R sprain     t,teammate none
                                                            ankle     fascia   R hemorrhage t,teammate none
```

Figure 17. Injuries occurring on artificial turf or surface (partial listing).

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                    Y A L E   A T H L E T I C   M E D I C I N E   R E P O R T I N G   S Y S T E M
03/04/81                                                                                                          PAGE  1

TOTAL OF 8 INJURIES          New,1st visit  2    Recur-season  1     Recur <1 yr  1      Recur >1 yr  1      Follow-up  3

SEARCH PARAMETERS:
Date Restriction:  None
Disability Time Restriction:  None

Primary Search:  Morphology--tear

Other Restrictions:
Region--knee           Tissue--cartilag

                                                 SURFACE   TIME       TOPOGRAPHY
NATURE  OCCASION  SPORT   LV S  ACTIV.  TYPE  COND.  LOST   REGION   TISSUE  S MORPHOLOGY ETIOLOGY  FUNC.        PROCEDURES

09/19/80  073-56-0191  Injury# 001                         DX:  TORN LATERAL MENISCUS
fol/up   sprt,nos footb,tk V  M tackled grass norml 5-7 d  knee     cartilag L tear        unknown    None   xray,pos maj.surg

02/09/81  092-50-9570  Injury# 002                         DX:  TORN MENISCUS
fol/up   sprt,nos lacrosse V  M running dirt  norml 2-4 d  knee     cartilag L tear        trauma,nos none   act.rstn

11/07/80  194-58-5145  Injury# 004                         DX:  POST LATERAL KNEE PAIN, L
new,1st comp.2nd footb,tk JV M block-  grass norml 1 day   knee     cartilag L tear        traum,self none   x-ray    ace
                                                           knee     joint    L hemorrhage traum,self none

10/25/80  214-46-8460  Injury# 004                         DX:  LATERAL MENISECTOMY
fol/up  training footb,ot IM M turning grass norml >1 mn   knee     cartilag L joint abnl traum,self none   maj.surg
                                                           knee     joint    L tear        traum,self none

01/26/81  277-46-7798  Injury# 004                         DX:  INTL. DERRANGEMENT, KNEE
recur-s training lacrosse -- - running aspht  --    none   knee     cartilag R joint abnl t,teammate none
                                                           knee     joint    R tear        t,teammate none

09/23/80  277-46-7798  Injury# 001                         DX:  TORN MEDIAL MENISCUS
recur>1 practice footb,tk FR M running grass norml 5-7 d   knee     cartilag R tear        traum,self none   xray,pos arthrosc maj.surg
                                                           knee     cartilag R tear        traum,self none   exercise

10/29/80  289-68-5668  Injury# 003                         DX:  TORN MENISCUS R KNEE
new,1st practice footb,tk V  M block-  grass norml 2-4wk   knee     cartilag R tear        t,opponent none   xray,pos ace      cast,on
                                                           knee     joint    R j-effusion t,opponent none   arthrosc

10/21/80  487-74-4067  Injury# 001                         DX:  TORN MENISCUS, CAPSULAR LAXITY
recur<1 not sprt    --      IN M jumping other norml none  knee     joint    R subluxed    trauma,nos none            cast,on
                                                           knee     cartilag R tear        trauma,nos none
                                                           knee     ligament R tear        trauma,nos none
```

Figure 18. Meniscal injuries.

In addition to injury searches, the system is useful for administrative functions. The disability list (Figure 7) informs coaches, trainers, and physicians as to who has not been cleared to return to play. Athletes placed on the disability list in one sport and never cleared for return will be unable to participate in any sport until follow-up examination is made. These capabilities are designed to protect the athlete's health be insuring necessary medical supervision. Administration of a computerized preparticipation medical history for athletes[22,23] could be used to generate a list of entering athletes requiring medical clearance before being allowed to engage in sports.

PART II

ANALYSIS OF COLLEGIATE SOCCER INJURIES

INTRODUCTION:

HISTORICAL

Several large scale studies of athletic injuries have included soccer players. Thorndike[3,4] studied injuries in intercollegiate (IC) and intramural (IM) sports at Harvard University for twenty-seven years (1932-1959). Injuries were recorded in the medical room at the field house. An index was kept by type of injury and body part. His analyses include only those injuries severe enough to result in an athlete missing one or more sessions of practice or competition. His large sample included soccer injuries, but his last tabulation included no calculation of injury expectancy or exposure rates because he felt that these statistics were "inconclusive".[4] Earlier he had reported fifty-five injuries to fifty soccer players with 2400 exposures (23 injuries per 1000 exposures, or 49 exposures per injury) and subsequently 8.6 injuries per 1000 exposures (116 exposures per injury).[3]

MacIntosh et al.[5] at the University of Toronto studied men's athletic injuries (both IC and IM) over seventeen years. Injuries were seen at the first aid room or university health service; a case loss of less than five percent was estimated. Soccer players comprised 7.7% of the participants and 6.4% of all injuries. Injury rates per 1000 participant-years (not per exposure) of 369 for IC and 61 for IM were reported. They estimated that 140 days play occurred before injury at the IC level. For soccer no statistics on the absolute number of players or injuries are presented. It is unclear exactly what the term "participant years" represents or how this denominator is calculated.

A number of reports have appeared over the years of studies solely of soccer injuries (Table 30). Featherstone[24] undertook a comprehensive

Table 30

Summary of Soccer Injury Studies

	Featherstone[24]	Bass[25]	Nilsson[26]	McMaster[27]	Sullivan[28]
Total Injuries	1164	290	858	60	34
By Type:					
Skin	26.5%	7.6%	39%	3%	--
Soft tissue	--	45.6%	--	--	--
Contusion	30.5%	--	36%	8%	38%
Sprain	12%	35%[1]	20%	35%	35%
Strain	14%	--		47%	9%
Concussion	--	--	1%	--	--
Fracture	1%	5.9%	3.5%	1.5%	6%
Other		3.8%[2]	0.5%	5.5%[3]	12%
By Location:					
Head/face	4%	--	10%	17.5%	8%
Torso[4]	6%	--	7%		4%
Upper extrem.	9%	--	15%	17.5%	5%
Lower extrem.	83%	83%	68%	65%	83%

Notes:
1. Includes all joint injuries.
2. Represents periostitis and cellulitis.
3. Represents dislocations.
4. Includes neck injuries.

study of a professional soccer club in Southampton, England over three years (1951-1954). The methods of data collection are not presented, although the injuries were apparently collected by a physician. The data occasionally conflicts from one tabulation to another. Nevertheless, he reports approximately1900 injuries, including 111 serious enough to result in at least one game being missed. The large total number is due to the fact that all injuries, even the most trivial, were recorded. A total number of exposures based on games alone (rather than games and practice sessions) is used to arrive at an average figure of 50 exposures before a serious injury occurred (20 injuries per 1000 game-exposure).

Bass[25] reported on 290 injuries for 136 different players over six years for another British soccer club. Criteria for inclusion or exclusion of injuries is not presented. Bass notes that virtually all injuries occurred during competition, an assertation at odds with most other published reports. He preceeds to calculate the number of "player-risk-hours" based on eleven players in 1236 games for one and one half hours each. This would yield a rate of 14 injuries per 1000 player-risk-hours.

Nilsson and Roaas[26] recorded injuries at the "Norway Cup," an international youth soccer (age 11-18) tournament held each year over six days and involving approximately one thousand teams. Free medical care was provided for all participants by seventy allied health personnel supervised by two physicians. A total of 1534 visits were made in two tournaments. Of these only 858 were injuries occurring during competition, 485 were other injuries, and 1919 were cases of illness. It is not clear whether these other injuries occurred during practice or entirely off the field. As a result of the free medical care, a large number

of routine skin abrasions and blisters were recorded. Approximately ninety percent of those injured could return to play the following day.

McMaster and Walter[27] collected data over one season of play of an American professional soccer club with a roster of fifteen players. A physician was present at all games and available for consultation at other times. Sixty injuries were recorded, 58% during competition and 42% during practice, and all resulted in at least one missed day. Seven injuries resulted in a week or more of lost time. No exposure data is supplied or attempt is made to calculate rate of injury.

Sullivan _et_ _al_.[28] reported on injuries in youth soccer (ages seven through eighteen) in soccer clubs in Western Oklahoma; half of the players were under ten years old. Data was collected from coaches and parents of athletes by mail and followed up by telephone. Thirty-four injuries were found, including seventeen in which the player missed more than seven days. Data from such a survey cannot be regarded as accurate or meaningful.

A study of soccer injuries with the Yale Athletic Medicine Reporting System will allow retrieval of comprehensive information about the circumstances surrounding the injury and a multiaxial description of the injury itself. Injuries can be automatically broken down by level and sex of the athletes. They can then be reviewed by one observer to be categorized by type of injury. Tabulation according to many different parameters, for instance, field type, field condition, or occasion can then be made. Data describing the occurrence of the injury has been obtained from the athlete him or herself. Each injury coded has been reviewed by a physician before being entered into the computer. These advantages insure a careful and accurate study.

METHODS

Using the computerized athletic injury reporting system described in Part I, injuries were retrieved for the Fall 1980 soccer season at Yale University. Athletes were divided into three groups: (1) varsity and junior varsity (JV) men, (2) varsity women, and (3) intramural (IM) athletes. The men's varsity and JV squads were placed in one category because there was overlap between the rosters. The fall intramural soccer season is classified as mixed because there are not minimum requirements for the number of women participants. However, greater than ninety-seven percent of the players are men. Information on number of athletes, practices, and games was obtained from the soccer caoches and the intramural office.

Injuries included in the study were only those which (1) resulted in the removal of the athlete from the practice or game, (2) resulted in loss of one or more days of practice or competition time, or (3) required significant medical attention (e.g. special taping) before the athlete's return to participation was permitted. A major injury was defined as one that caused an athlete to miss seven or more days of practice or competition.

An occasion of exposure was defined as one period of practice or one game for a single athlete. This is used to estimate the number of occasions of risk of injury. For example, a team with twenty athletes all engaging in five practices and one game would represent 120 occasions of exposure. For varsity teams, total exposures was calculated from the number of athletes on the roster, practices and games per week, and the length of the season. For intramural teams the total number of exposures

was obtained from attendance sheets used at all games, as intramural do not engage in significant amounts of practice other than directly prior to games.

Statistical significance of results was tested* by assuming that the injuries occurred as random events in time and applying a Poisson distribution to calculate the variance.[29] On the null hypthesis that the rate of injuries in both groups is identical, a comparision of variances is made. The result is taken as an approximately standardized normal deviate to arrive at a significance limit. If the results are significant, another determination of variance assuming a ten persent error in number of exposures is used to calculate a more conservative significance limit.

---

* With the assistance of Dr. Stephen Walter, Associate Professor of Public Health (Biometry), Yale University School of Medicine.

RESULTS

Table 31

Number of Athletes, Exposures, and Injuries

	Varsity Men and JV Men	Varsity Women	Intramural	Total
Athletes	40	24	403	467
Exposures	2880	1488	1977	6345
Exposures/athlete	72	62	4.9	14
Injuries:				
Total	48	20	42	110
Major	10	3	13	26
Injuries per 100 athletes:				
All	120	83	10	24
Major	25	13	3	6
Injuries per 1000 exposures:				
All	17	13	21	17
Major	3.5	2.0	6.6	4.1
Average number of exposures before:				
Any injury	60	74	47	58
Major injury	288	496	152	244

Number and Distribution of Injuries

A total of 173 visits by soccer players to the athletic medicine clinic for the period September 1 through December 31, 1980 were retrieved. Twelve visits were for medical problems. Due to a recording difficulty this represents only a small fraction of actual medical visits; thus, these were excluded from the study. Of a group of 467 soccer players, 81 different athletes were seen for 110 unique injuries (Table 31).

Table 32

Distribution of Injuries Amongst Athletes

Number of athletes with:	Varsity Men and JV Men #	%AT	%IN	Varsity Women #	%AT	%IN	Intramural #	%AT	%IN
No injuries	12	30	0	11	46	0	362	90	0
1 injury	16	40	33	10	42	50	40	10	95
2	7	18	29	2	8	20	1	.25	5
3	3	8	19	0	-	-	0	-	-
4	1	2	8	0	-	-	0	-	-
5	1	2	11	0	-	-	0	-	-
6	0	-	-	1	4	30	0	-	-
Total athletes	40			24			403		

Key: %AT = percent of total athletes.
%IN = percent of total injuries.

Twenty-six injuries resulted in the loss of seven or more days of practice and competition time (major injuries). There were no injuries resulting in paralysis or death.

For the varsity teams there was no significant difference ($p>0.05$) between the number of men (28 out of 40) and women (11 out of 24) suffering at least one injury. For the men a total of 30% of the squad were responsible for 67% of the injuries; for the women 3% were responsible for 50% of the injuries (Table 32). In comparison to the varsity teams, very few intramural players (41 of 403) suffered an injury ($p<0.01$). Fifteen injuries (14% of total) were classified as recurrences of one type or

another. Five of these recurrences were major and one was minor but followed a major injury.

Overall, there were 17 injuries per 1000 exposures or an average of 58 exposures elapsing before injury (Table 31). The differences between the rates for the individual groups are not significant ($p>0.05$); if these rates are accurate it would require approximately three more seasons to make the numbers statistically significant. Major injuries occurred at an overall rate of 4.1 per 1000 exposures, with a significant difference ($p<0.05$) only between women's varsity (2.0 per 1000) and intramural (6.6 per 1000).

Types of Injuries

Sprains and contusion each represented about 35% of the total injuries. An addition 5% were classified as unspecified soft tissue injuries; these were all combinations of minor sprains and contusions (Table 33). Amongst the individual squads the proportions were disparate: men's varsity and JV had 44% contusions and 21% sprains, intramurals had 24% contusions and 50% sprains (difference between contusions not significant, $p>0.05$; sprains significant, $p=0.05$), and women's varsity was intermediate. Major contusions comprised 27% of major injuries while major sprains comprised 42%; these figures were similar for all squads. Overall, ankle sprains were most common (55% of sprains) followed by knee sprains (28%). This order was also true for the men's squad and intramurals, but was reversed for the women's squad, where the knee (56% of sprains) exceeded the ankle (22%). Contusions occurred almost equally at the thigh, leg, and foot.

Table 33

Type of Injuries

	Varsity Men and JV Men		Varsity Women		Intramurals		Total	
	* No. (maj)	%	No. (maj)	%	No. (maj)	%	No. (maj)	%
Skin	1	2	0	0	3 (1)	7	4 (1)	4
Soft tissue	4	8	2	10	0	0	6	5
Contusions	21 (3)	44	7 (1)	35	10 (3)	24	38 (7)	35
upper	1	2	1	5	2	5	4	4
torso	1	2	0	0	0	0	1	1
thigh	6 (1)	13	2	10	2 (2)	5	10 (3)	9
knee	2	4	0	0	2	5	4	4
leg	4	8	3 (1)	15	3 (1)	7	10 (2)	9
ankle	1	2	0	0	0	0	1	1
foot	6 (2)	13	1	5	1	2	8 (2)	7
Sprains	10 (4)	21	9 (1)	45	21 (6)	50	40 (11)	36
upper	0	0	2	10	2	5	4	3.5
knee	1 (1)	2	5 (1)	25	5 (4)	12	11 (6)	10
ankle	9 (3)	19	2	10	11 (2)	26	22 (5)	20
foot	0	0	0	0	3	7	3	2.5
Strain (low.)	4	8	0	0	4 (1)	10	8 (1)	7
Concussion	3 (2)	6	0	0	2	5	5 (2)	4
Fracture	1 (1)	2	1 (1)	5	1 (1)	2	3 (3)	3
Inflammation	0	0	1	5	1 (1)	2	2 (1)	2
Back	3	6	0	0	0	0	3	3
Subluxation	1	2	0	0	0	0	1	1
Totals	48 (10)	100%	20 (3)	100%	42 (13)	100%	110 (26)	100%

---

* Listed are total number of injuries;
Major injuries appear in parentheses.

Strains comprised only seven percent of the total injuries with only one classified as major; no strains occurred on the women's squad. Concussions represented four percent of injuries including three on the men's squad; two of these were major and required hospitalization.

Three fractures occurred; the most serious, a tibia-fibula fracture on the JV men's squad. This occurred as the athlete was kicking a shot on goal and the goalkeeper dove feet first into the forward's leg in an attempt to block the ball. Other fractures were a metatarsal stress fracture to a varsity woman and a great toe fracture to an intramural athlete. All three fractures were classified as major by time lost criteria despite the obvious disparity in severity.

In the inflammatory category were a case of prepatellar bursitis and one of chondromalacia. Three varsity men suffered minor low back injuries with negative x-ray findings.

Region

Lower extremity injuries accounted for 83% of the total and 92% of major injuries (Table 34). Overall, these were fairly equally divided between regions with a slight predominance of ankle and knee injuries. Head and facial injuries comprised eight percent of the total, including two major injuries, the concussions mentioned above. Injuries to the torso and upper extremity represented four and five percent of the total, respectively, with absence of any major injuries.

Occasion

Injuries during competition accounted for 57% of the total and 69% of major injuries (Table 35). Thirty-two percent of all competition

Table 34

Body Part Involved in Injury

Region	All Injuries No.	All Injuries %	Major Injuries No.	Major Injuries %
Head/face	9	8	2	8
Torso	4	4	0	0
Upper extremity	6	5	0	0
Lower extremity	91	83	24	92
thigh	13	12	3	12
knee	21	19	9	34
leg	16	15	3	12
ankle	24	22	5	19
foot	17	15	4	15
	110	100%	26	100%

Table 35

Occasion of Injury

Occasion	All Injuries No.	All Injuries %	Major Injuries No.	Major Injuries %
Sports related, NOS	10	9	0	0
Practice	21	19	5	19
Scrimmage	7	6	3	12
Training	1	1	0	0
Competition, total	63	57	18	69
not specified	20	18	4	15
1st half, 1st part	5	5	2	8
1st half, 2nd part	10	9	3	12
2nd half, 1st part	22	20	6	23
2nd half, 2nd part	6	6	3	12
Not sports related	3	3	0	0
Nonacute onset	5	5	0	0
	110	100%	26	100%

injuries did not specify the time of occurrence while 35% happened during the first part of the second half. Practice, scrimmage, and training accounted for 26% of all injuries while another 9% were listed as sports related but not otherwise specified. The men's varsity and JV group and the women's varsity squad showed a slightly higher proportion of injuries during practice activities.

When the difference in number of exposures to practice and competition is taken into account, there is a significantly higher rate of injuries during competition for both varsity squads (Table 36). For the men's squad there is also a significantly increased rate of major injuries during games; for the women's squad the difference is not statistically significant because of the small number of major injuries. There is no significant difference ($p>0.05$) when comparing the rates of the two squads to

Table 36

Injury Rates in Competition and Practice for Varsity Teams

		Varsity Men[1] and JV Men		Varsity Women	
		Compet.	Pract.	Compet.	Pract.
Exposures[2]		515	2365	312	1176
Injuries:	Total	25	14	11	9
	Major	6	4	2	1
Inj./1000 exp.	Total	49	5.9 ($p<0.01$)	35	7.7 ($p<0.05$)
	Major	12	1.7 ($p<0.05$)	6.4	0.85 ($p>0.05$)

Notes: 1. Excludes nine injuries classified as sports related unspecified (4) and not sports related or nonacute (5).

2. Competition exposures from: Varsity Men — 23 athletes, 15 games; JV Men — 17 athletes, 10 games; Varsity Women — 24 athletes, 13 games.

each other.

Surface Type

The only teams to play on artificial turf were varsity men (three games, two practices) and JV men (one game). There were eight injuries during these exposures, including two on wet or irregular turf (Table 37). Injury rates of 93 per 1000 game-exposures for artificial turf and 35 per 1000 game-exposures for grass are significantly different ($p<0.02$). Of the injuries on grass, about 75% were under normal conditions and 25% were on wet, irregular, hard, or muddy surfaces.

Table 37

Surface Type Associated with Injury

Surface:	Varsity Men and JV Men No.	Varsity Men and JV Men %	Varsity Women No.	Varsity Women %	Intramurals No.	Intramurals %	Total No.	Total %
Not specified	8	17	0	0	3	7	11	10
Grass, normal	23	48	15	75	31	74	69	63
Grass, *abnormal	9	19	5	25	8	19	22	22
Artificial, nl	6	12						
Artificial, *abnl	2	4						
	48	100%	20	100%	42	100%	110	100%

* abnormal = wet, irregular, hard, or muddy.

DISCUSSION

In medicine an incidence rate measures the frequency of occurrence of a disease. In order to calculate an incidence one needs to know the number of new cases that arise during a specified time interval and the number of persons at risk but free of the disease. Athletic injuries are difficult to quantify in this way because the population is only at risk for injury during certain periods of time each day. Thus, the rate of athletic injuries is dependent on the number and duration of practices and games, as well as other factors. It would be necessary to know the total number of man-hours of athletic time to use as a denominator in order to calculate a rate. An accurate determination of man-hours would require knowing the time spent practicing and in actual competition for each individual athlete. In colleges with large and diversified athletic programs this is extremely difficult and in most cases not feasible. This, however, should not be the reason to make no attempt to quantify data, as one finds with many studies.

The concept of "occasions of exposure" as representing a denominator for use in rates has been advanced.[3,11] Each athlete participating in a practice or game is taken as one unit of exposure. This is an approximation in that no differentiation is made for lengths of practice or playing time. However, this is still a worthwhile attempt to obtain a rate analogous to an incidence.

Some authors have calculated the number of injuries per a unit number of athletes. This parameter is susceptible to a large variation based on the amount of time each player spends on athletic activities. Therefore it is unsuitable for comparison between sports and levels. For example,

in our study it was found that a varsity soccer player might participate in twelve to fifteen games as well as fifty to sixty practice sessions, while an intramural soccer player might only play in ten to twelve games.

The present study analyzes 110 soccer injuries, an amount intermediate among the studies discussed above. Similarities can be noted for the distribution of injuries by body part (Tables 30 and 34) in that all have found a predominance of lower extremity injuries, including a figure of 83% from this study. Differences can be seen in the distribution of types of injuries (Tables 30 and 33) probably based on differences in recording criteria. Those studies that include fairly minor injuries may report a disproportionate number of skin lesions and muscle strains. Different levels of play, ranging in these studies from youth to professional soccer, may result in different patterns of injury.

The injury rate per 1000 exposures reported here are similar to Thorndike's results[3]; he is the only author who has used a comparable method, but only in his earlier reports. For the data presented here, due to the small sample size, it is not possible to make any conclusion about the relative safety of the three groups studied based on the overall injury rates. If the injuries were to continue at the same rates it would require approximately three additional seasons of data for the small differences to be statistically significant.

The distribution of injuries among athletes reveals that only a small proportion of intramural players suffer any injuries. This may be due to several reasons: These may represent athletes who have taken part in many more games than average and thus have a higher number of occasions of exposure. These could be a group of less highly trained and less highly skilled athletes who are thus more susceptible to injury. Also, these

may be athletes who have poor quality equipment or even lack proper equipment. The intramural athletes, comprised almost entirely of men, also had significantly more sprains than the men's varsity and JV squad. In soccer a sprain is an injury associated with the more poorly conditioned, less highly skilled athlete, which may explain why there is a higher rate among the intramural players. Varsity players, who tend to be more highly trained and skilled and with better endurance, have the ability to better cover opponents, resulting in increased body contact. This, along with the more intense competitive nature of varsity games, explains the higher proportion of contusions found on the varsity and JV men's squad.

It has been recognized by many coaches and athletes that more injuries seem to occur during games than practices. In a game the athlete is driven by a competitive spirit unlikely to manifest itself when scrimmaging against teammates. Only slightly over half of the varsity injuries reported here occurred during competition, but these represent a much smaller number of exposures. As a result, both total varsity injury rates (as well as the major injury rate for men) are significantly higher during competition than practice. The high proportion of injuries reported in the first part of the second half of the game deserves consideration. Although most teams have elaborate pre-game exercises, it is not unusual to see players sitting in a team meeting during half time and returning to play without any significant warm-up. Also, after a half time "pep talk", the losing team may be more likely to begin the second half with more aggressive play, resulting in an increased number of injuries.

The appearance of artificial surfaces in college sports facilities has sparked renewed debate about their safety. In this study the varsity and JV men's teams played a total of four games and two practices on artificial turf. This sample of exposures contains a higher proportion of the total number of games than of the total practices. Since there is a higher underlying rate of injuries during competition it is inappropriate to compare overall injury rates for the two surfaces without correction. One can calculate injury rates during competition only (per 1000 game exposures) for comparison. The result is a significantly higher rate of injuries during games on artificial turf than on grass. Most of the athletes in this study used a special artificial turf shoe which provides excellent traction on wet turf but occasionally too much traction on dry turf. The decreased maneuverability due to excessive traction may result in increased ligamentous injuries. In future seasons a flat training shoe will be used when playing on dry artificial turf in an attempt to decrease the number of injuries.

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